An Introduction to ERA-5 and the Eurosip seasonal forecasts: overview of the products and the system

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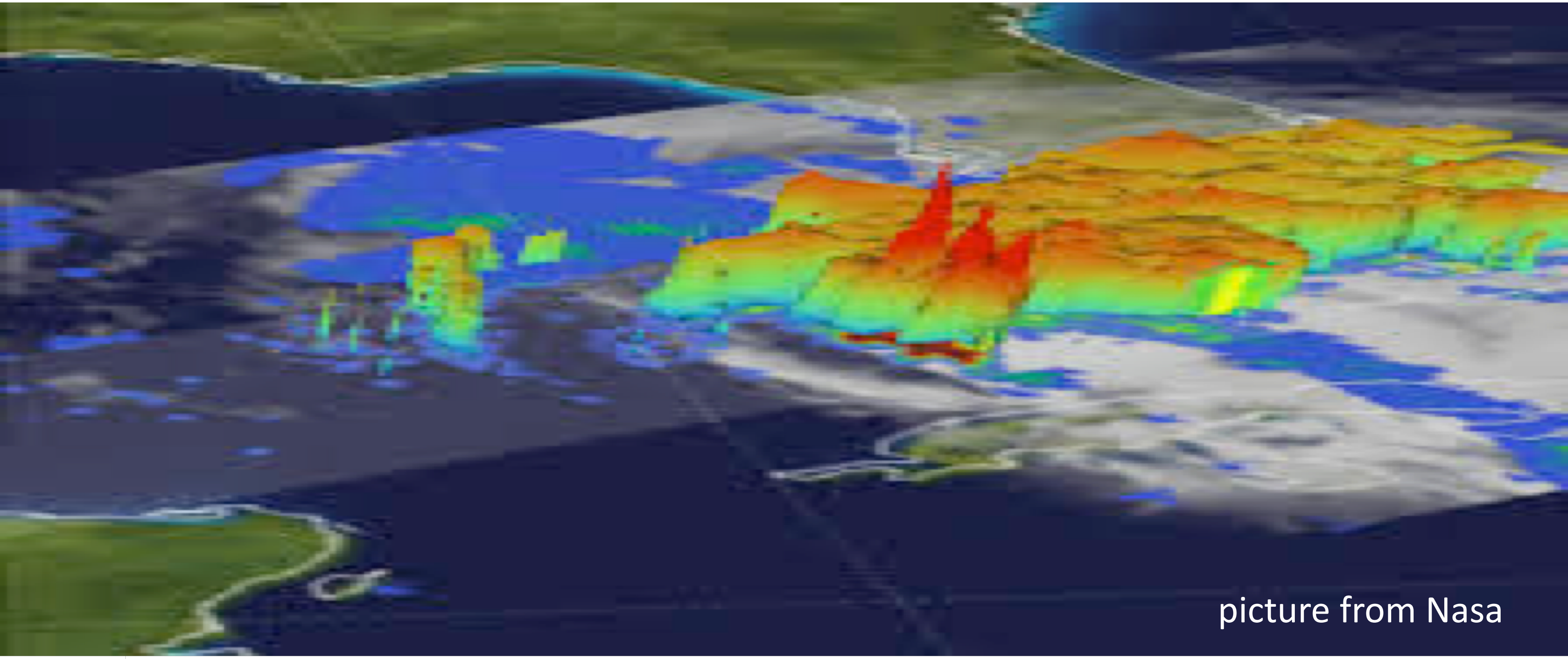
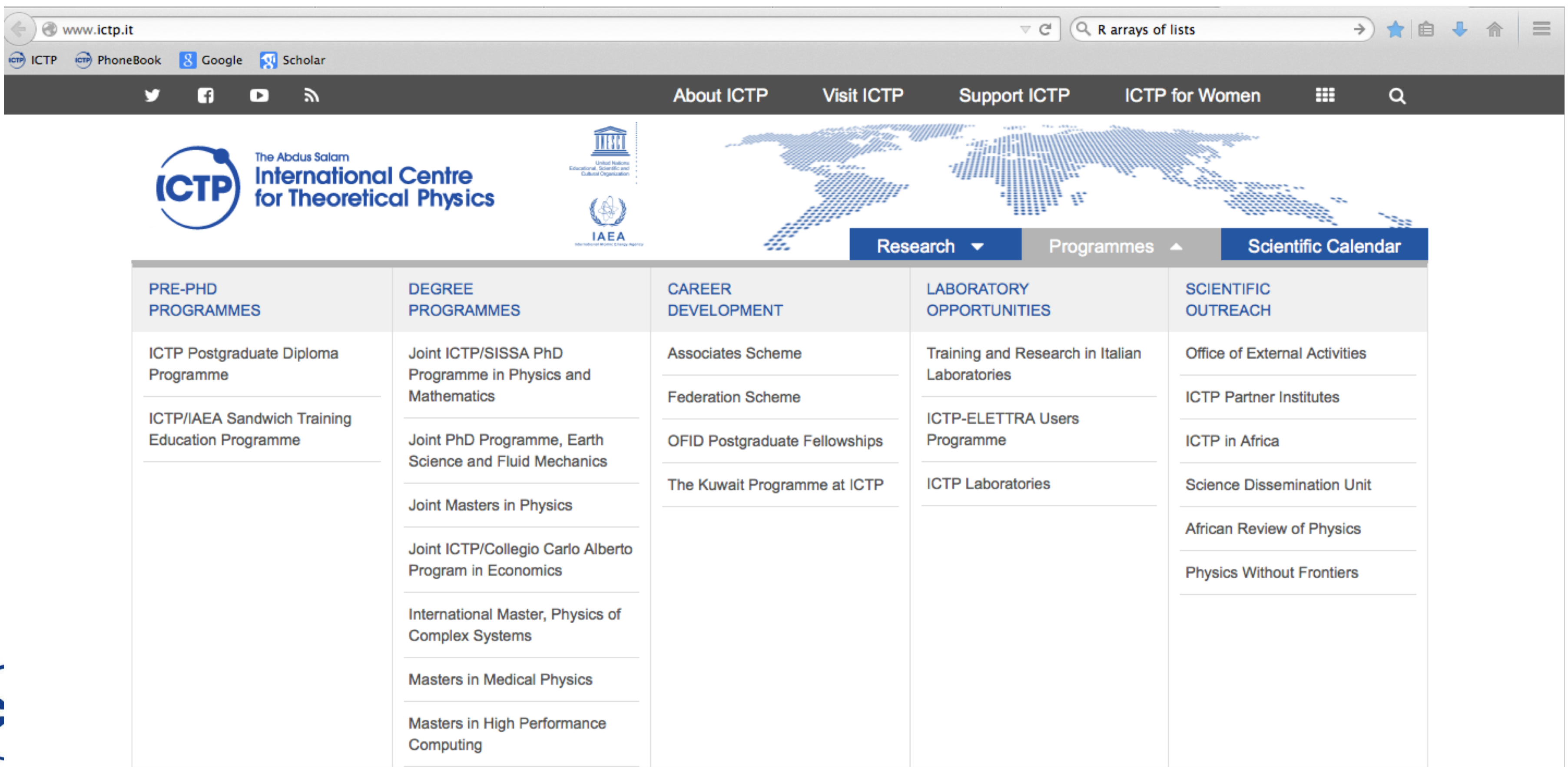


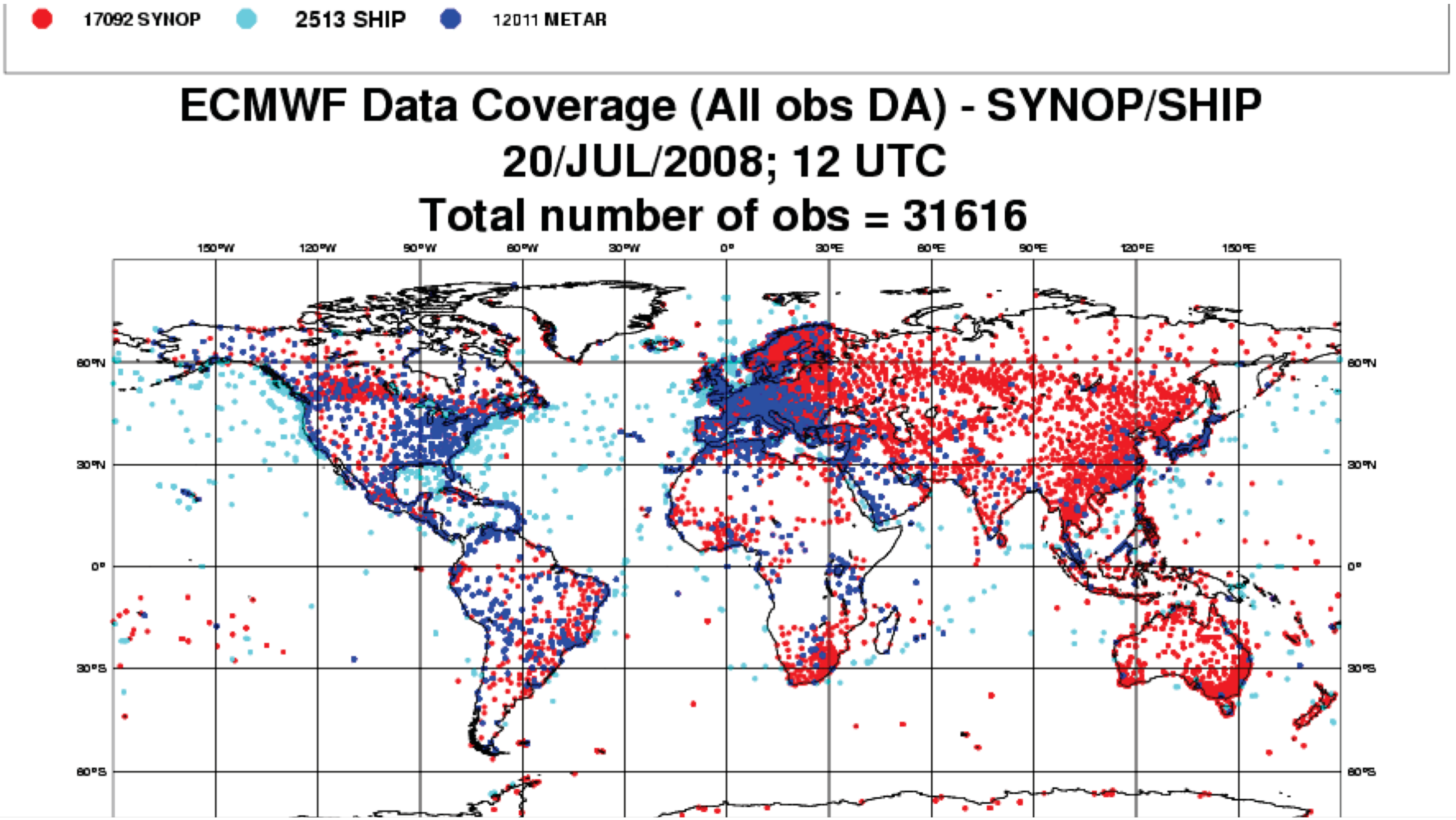
ICTP

- ICTP Diploma – one year fully masters-like programme in earth system sciences.
- STEP – sandwich PhD programme. joint supervisors, 6 months visit each year
- Associate programme – junior to senior, 3 visits in 6 years.

- Oceangraphy
- Regional climate modelling
- Aerosols (REGCM)
- Teleconnections (Speedy)
- Health Applications (VECTRI)
- Hydrology (CHYM)
- Solid earth geophysics
- Computing



Sources of data: stations



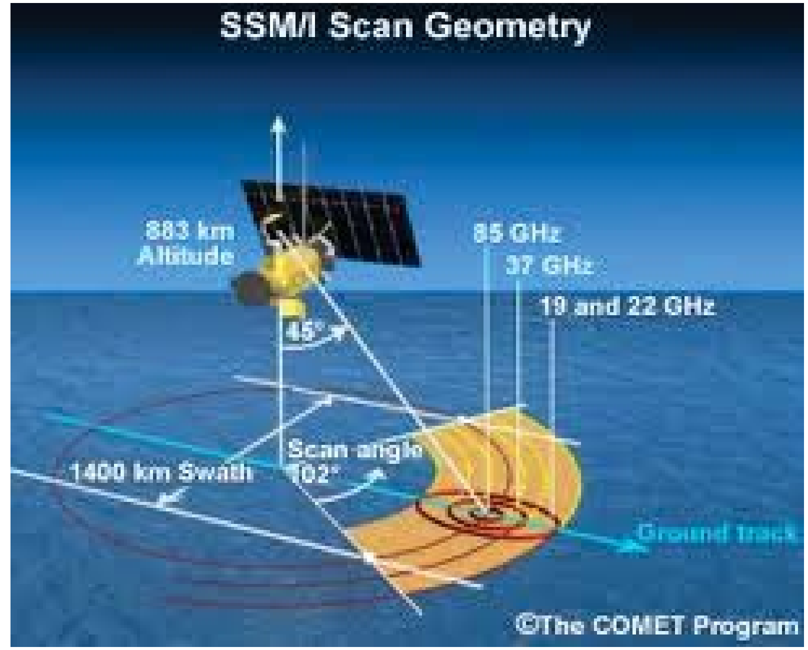
Station Data: Advantages and Disadvantages

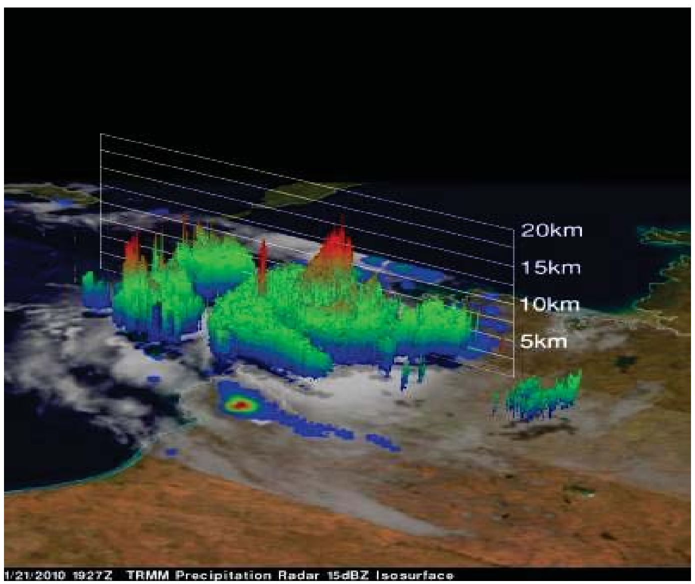
- Full array of variables
- Locally representative

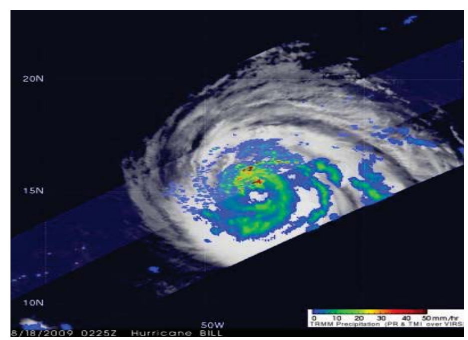
- Not often available locally
- Potentially data gaps, handling of bad data
- Representativeness over complex terrain

Satellite Data

- Surface Temperature
- Precipitation
- Humidity
- Winds

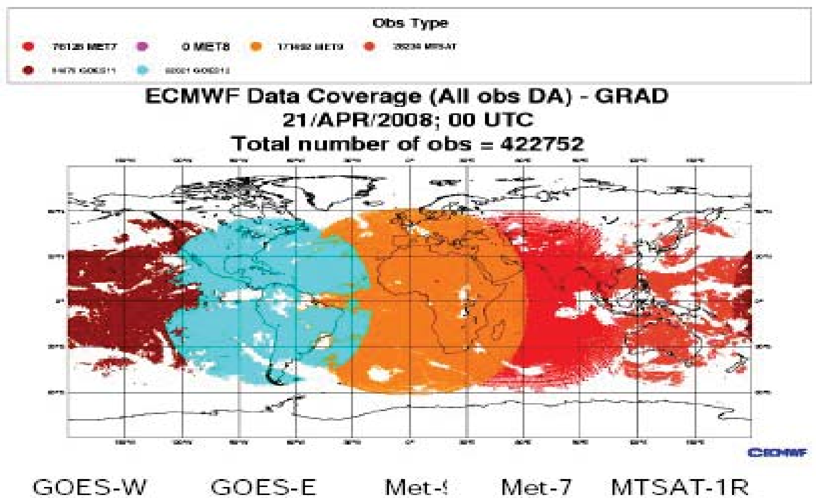




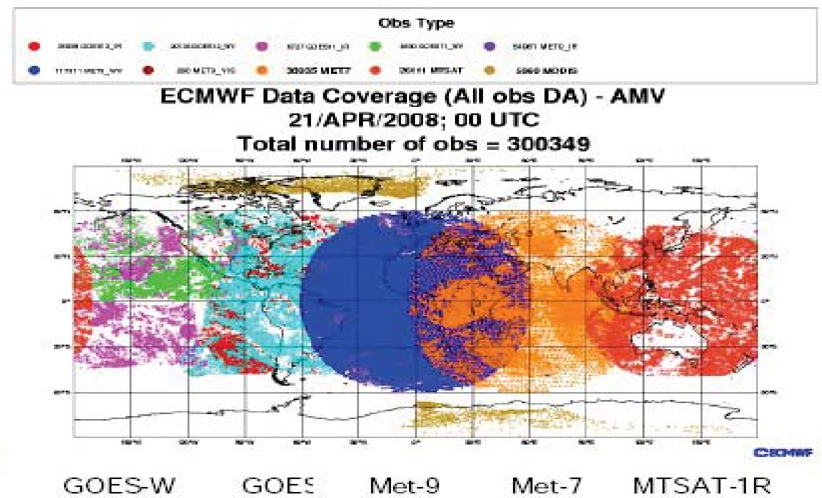


For Satellite – coverage can be less of an issue (polar or geostationary – resolution, swathe, return times)

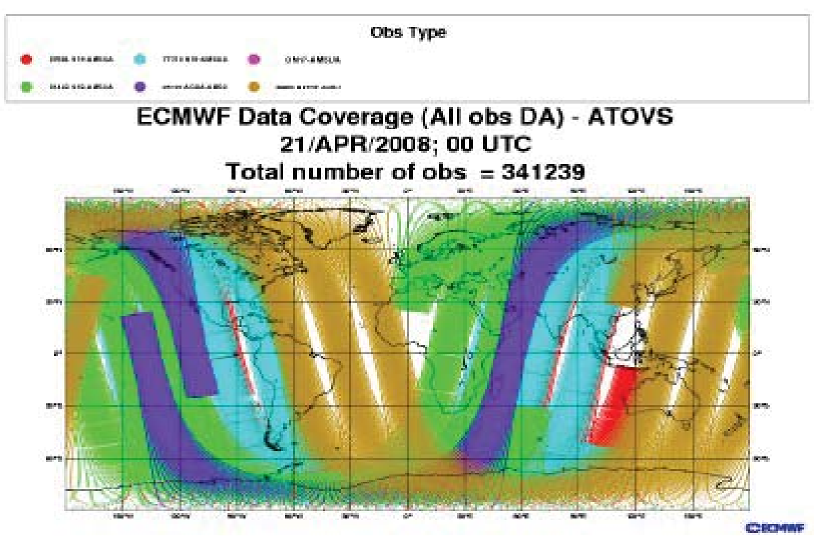
Clear-sky radiances



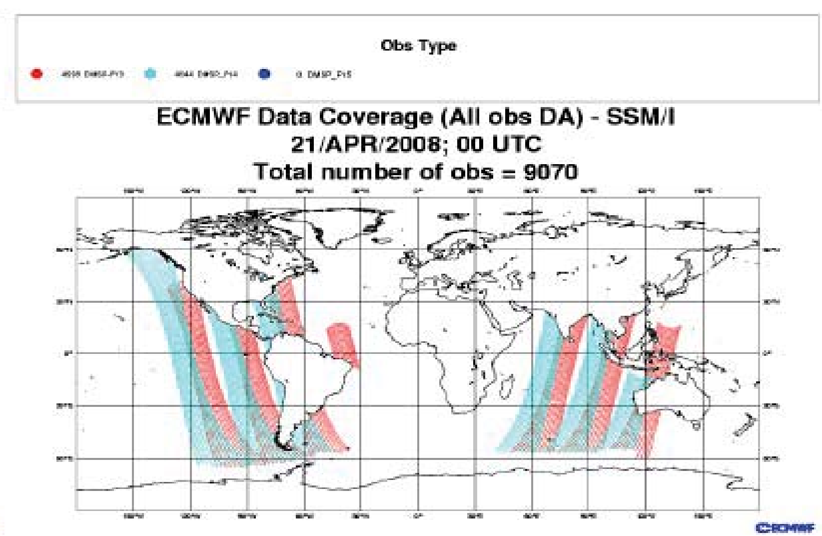
Atmospheric Motion Vectors



AMSU-A



SSM/I



Satellite – advantages and disadvantages

- Good spatial and/or temporal coverage (depending on swathe, scan, orbit...)
- Only way to get regional information in conventional data-sparse regions

- Large uncertainties
- Temperature is skin temperature
- Problems for clouds, aerosols, insects etc
- Vertical resolution of atmospheric variables poor
- Problems in many retrievals mechanisms over land

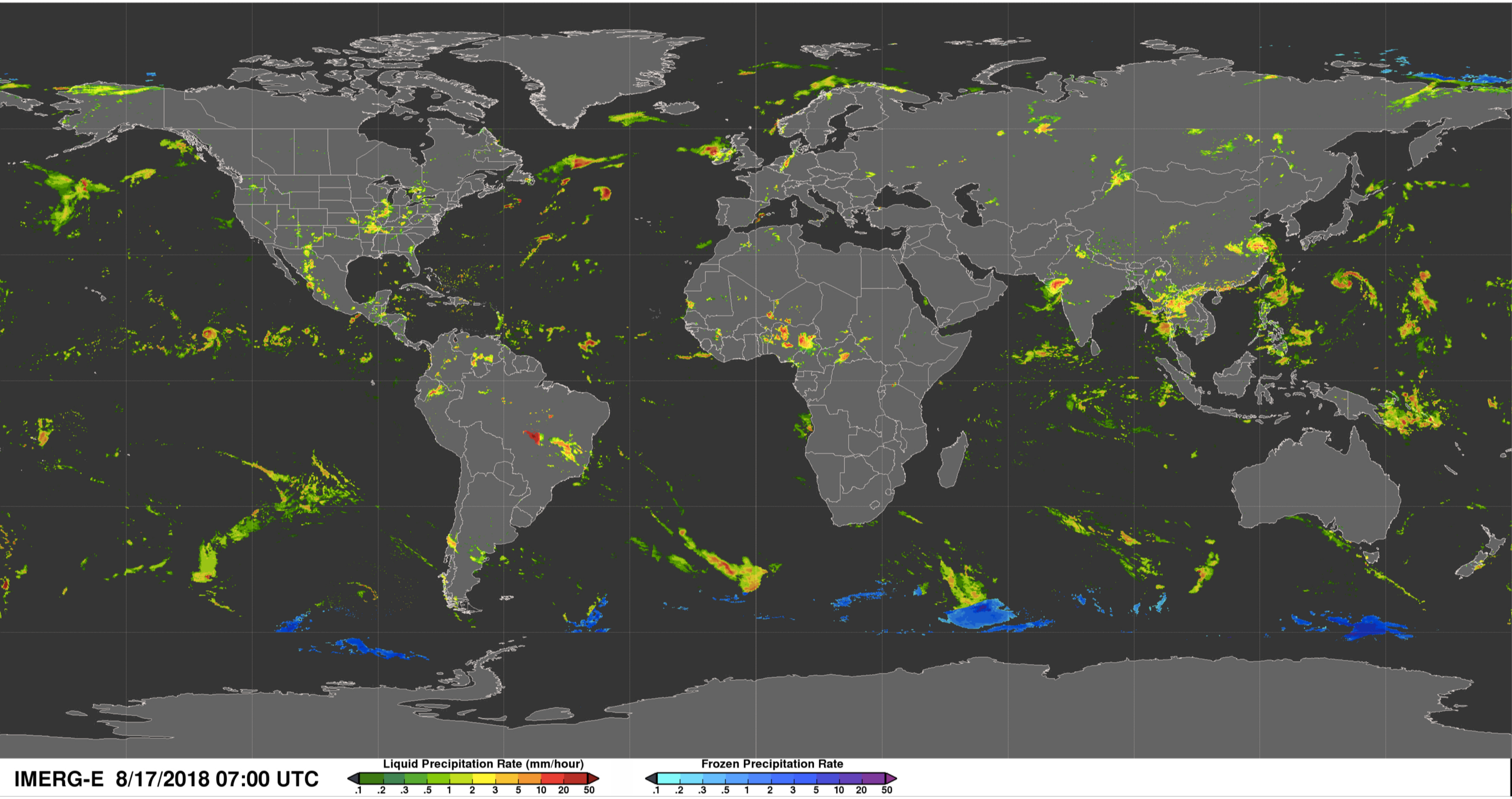
Wide Choice of retrievals: e.g. Precipitation

- GPCP – 1995 daily (1 deg), 1979 monthly (2.5 deg) – not real-time. Mix of IR and raingauge
- CMAP – Similar to GPCP – monthly only at 2.5deg
- CMORPH – 2003-present, realtime. 30 mins. based on microwave channels, using IR to provide temporal resolution. 25/8km.
- FEWS – daily, only over Africa, using gauge if nearby, otherwise combination of IR/microwave channels, 11km resolution. Realtime, 2000-present.
- TRMM – 25km resolution, 1998-present, 3 hourly.
  - 2A25 – precip radar product – not gridded
  - 3B42 – merged, radar, IR and microwave using gauge calibration – realtime

What to use?
What is best?

since 2014: GPM@10km!!!

A GPM example



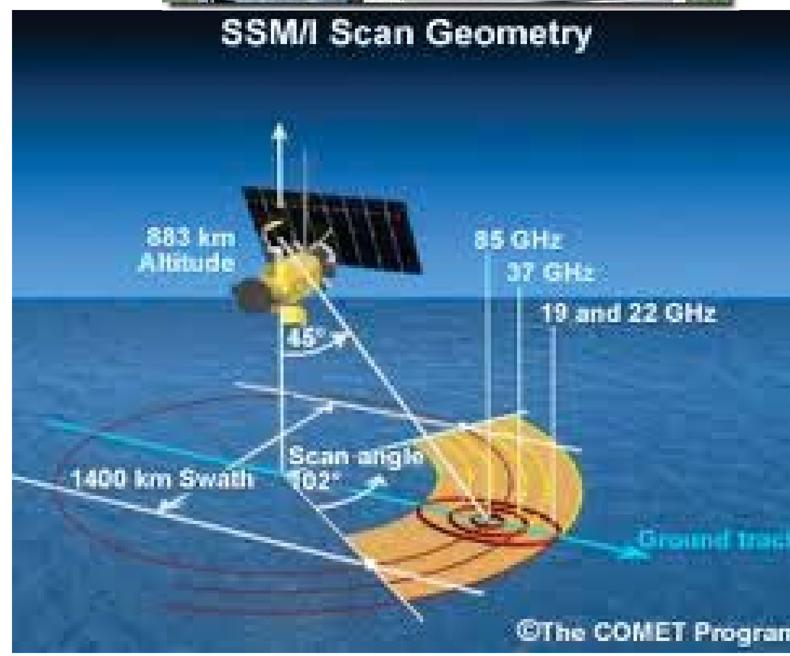
is this better?

But some variables in contrast are difficult to get directly from Satellite

- Surface temperature: reliable over oceans using microwave. Some products over land, but uncertainty is large and not available daily
- Winds: reasonable over oceans using scatterometer data, surface winds over lands not possible. Upper level winds from feature tracking (cloud, humidity) but uncertainties high.
- Humidity: near surface only indirectly.
- Take home message: most (near) surface variables **over land** very difficult to infer from remote sensing

Take home messages

- Station data are good where they exist, but they require careful treatment
- Satellite data useful for a regional view, but uncertainties are large, not all parameters are available, and the retrieval techniques are often obscure.



A supplement source of climate information: analysis and reanalysis

- To make forecasts of the future weather, knowledge of the present state is required
- This "picture" of the atmosphere needs to be "balanced" – Simple spatial and temporal interpolation of observations doesn't work
- Hence the development of analysis systems

ICTP

Aim of “Data Assimilation” System

- To take a wide variety of variables (not necessarily model variables)...
- ...from a wide variety of instruments...
- ...with vastly different measurement densities...
- ...taking care to reject bad measurements...
- ...and combine them into an assessment of the atmospheric state, that is near balance with the forecast model “climate”
- Sounds Easy?

We introduce the concept of data assimilation by first discusses the concept of the best linear unbiased estimate of a state variable x at time t. Let's assume that we have two observations o_1 and o_2 of x_t, each with their respective (known) observational error (ϵ_i):

$$\begin{aligned} o_1 &= x_t + \epsilon_1 \\ o_2 &= x_t + \epsilon_2 \end{aligned} \tag{73}$$

We assume the mean statistical properties are known $\overline{\epsilon_i^2} = \sigma_i^2$, and that the observation errors are unbiased, that is $\overline{\epsilon_i} = 0$, and for simplicity and wlog we assume they are uncorrelated $\overline{\epsilon_1 \epsilon_2} = 0$.
We can derive an estimate of x_t, denoted x_a, as a linear combination of the observations such that $\overline{x_a} = x_t$ (the estimate is unbiased), and $\sigma_a^2 = \overline{(x_a - x_t)^2}$ is minimized (i.e. it is the best estimate):

$$x_a = \frac{\sigma_2^2 o_1 + \sigma_1^2 o_2}{\sigma_1^2 + \sigma_2^2} \tag{74}$$

(note the indices are reversed, i.e. the estimate with the greater error contributes least to the state estimate). We can alternatively find this estimate by calculating the value of x_a that minimizes a cost function $J(x_a)$:

$$J(x_a) = \frac{(x_a - o_1)^2}{\sigma_1^2} + \frac{(x_a - o_2)^2}{\sigma_2^2} \tag{75}$$

For Gaussian errors, this is the known as the maximum likelihood estimate.

If we have a vector of data observations $\hat{o} = (o_1, o_2, ..., o_n)^T$ we can generalize the cost function to

$$J(x_a) = (x_a - \hat{o})^T P^{-1} (x_a - \hat{o}) \tag{76}$$

where P is referred to as the error covariance matrix of $\hat{o}$. the diagonals of P are the uncertainty in each observation, while the off-diagonals elements are a measure of the correlation between observations (in space and between different variables, P is a large matrix!).

For our special case of uncorrelated errors P is a diagonal matrix.

and thus

$$J(x_a) = (x_a - o_1, x_a - o_2) \begin{pmatrix} \frac{1}{\sigma_1^2} & 0 \\ 0 & \frac{1}{\sigma_1^2} \end{pmatrix} \begin{pmatrix} x_a - o_1 \\ x_a - o_2 \end{pmatrix} = \frac{(x_a - o_1)^2}{\sigma_1^2} + \frac{(x_a - o_2)^2}{\sigma_2^2} \tag{79}$$

rederiving eqn. 75.

Now the problem of simply basing the state estimate on a number of direct observations are numerous:

- Observations come in a wide variety of forms (high density satellite information), sparse in situ radiosondes etc
- Not all observations are of direct model state variables (e.g. brightness temperatures and radiances are measured by satellite, not temperature and humidity directly)
- Observations have widely different error characteristics
- A direct combination of variables may lead to a unbalanced initial state

One solution is to combine the observations with a short term numerical forecast (3DVAR):

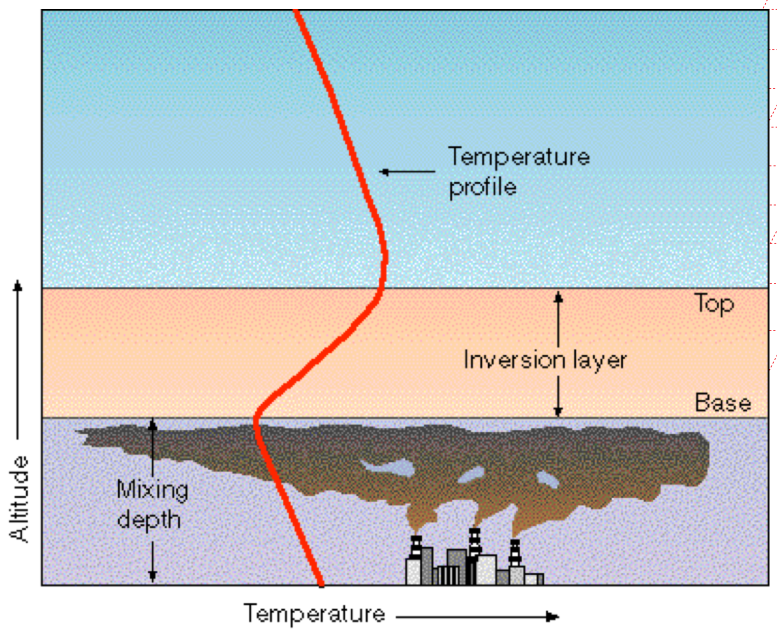
$$J(x_a) = (x_a - x_f)^T B^{-1}(x_a - x_f) + (\mathcal{H}(x_a) - \hat{o})^T E^{-1}(\mathcal{H}(x_a) - \hat{o}) \quad (80)$$

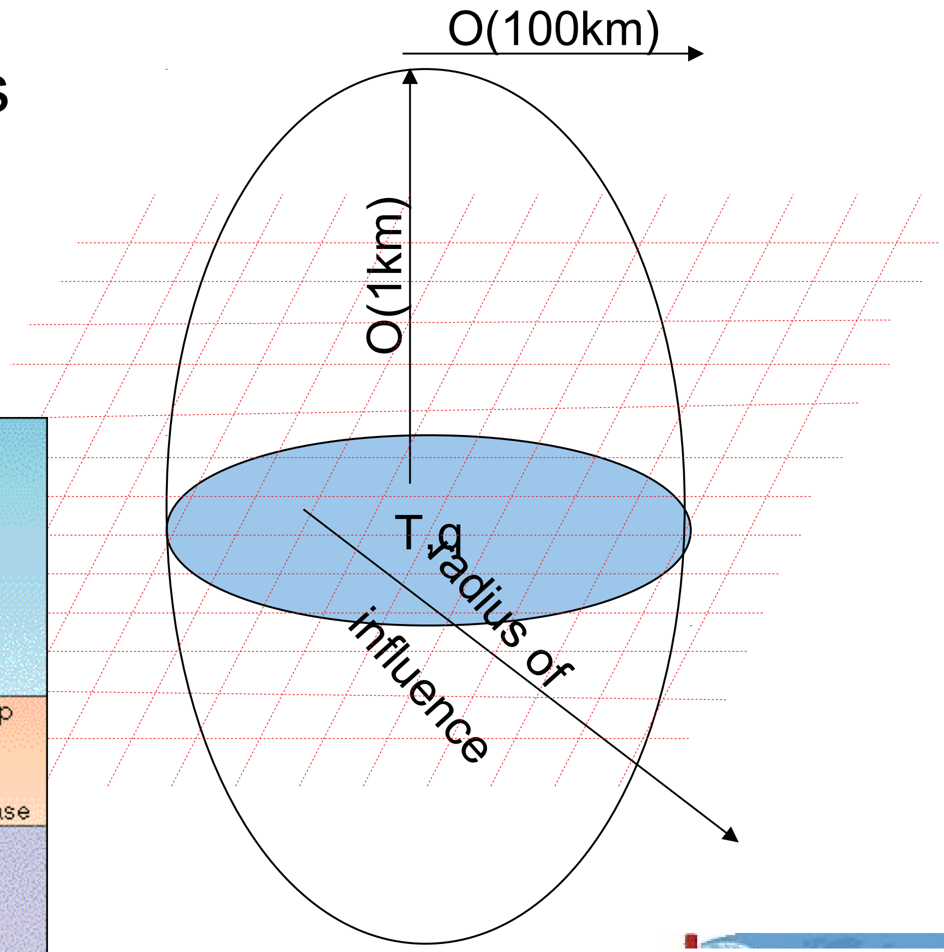
where x_a is now referred to as the analysis, x_f is the forecast, $\mathcal{H}$ is a function that transfers the analysis state into the observation space of the observations and is referred to as the forward model , and B and E are the forecast and observation error covariance matrix, respectively.

Defining B and in particular E is not straightforward and entails somewhat ad hoc assumptions about correlations of variables in space and time (Fig. 46).

Data assimilation

- Radius/distance of influence for each observation type needs to be defined
- Not obvious: e.g. Inversions, fronts etc.



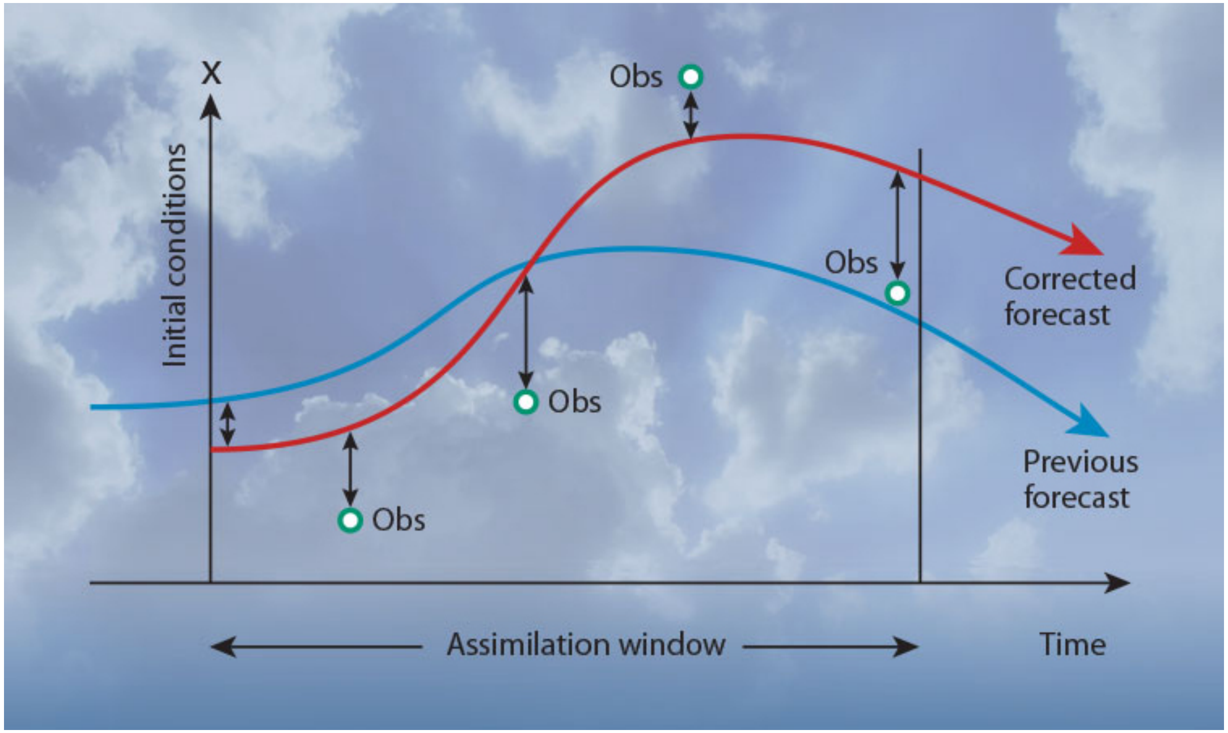


We can't solve eqn. directly to calculate x_a for which $\Delta J = 0$, the problem is simply too big (e.g. inverting the matrix)! Therefore we need to make an interative approach and to do that we need the calculate the gradiant of J:

$$\Delta J(x_a) = 2B^{-1}(x_a - x_f) + 2\boldsymbol{H}^T E^{-1}(\mathcal{H}(x_a) - \hat{o}) \tag{81}$$

Here $\boldsymbol{H}$ is the Jacobian of $\mathcal{H}$, referered to as the tangent linear model, and the transpose matrix $\boldsymbol{H}^T$ is the adjoint of $\mathcal{H}$. .
Interative incremental approaches to this minimization problem are needed to make the problem tractable with available computing resources.

The 3DVAR approach assumes all obversations within a time window (typically 6 hours, e.g. in the earlier ECMWF implementation) are made at the same time, but this leads to errors as systems are advected. 4DVAR generalize this by accounting for the time of the observations. The window (12 hours in ECMWF) is divided into one hour slots, and compared with a trajectory using the tagent linear and adjoint codes, that is, the state vectors are a function of time.



Thus the summary of the process is

- perform outer loop x_f
- reject observations for which $\mathcal{H}(x_f)_i - o_i$ is excessive (observation departures too large = bad data?).
- perform minimization of $J(x_a)$ to get first x_a
- Make new outer loop nonlinear integration x_f starting from revised x_a
- Repeat above until convergence (in practise n_{outer}=3).
- Take final analysis from desires time points within window

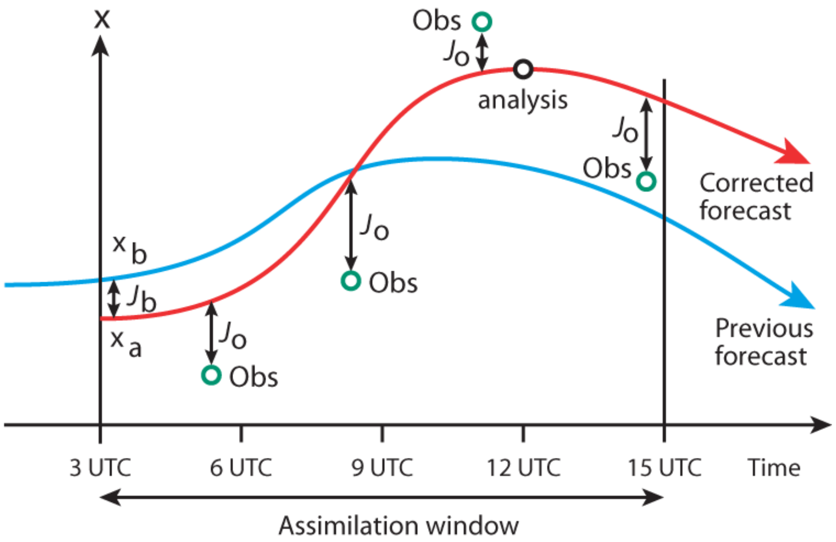
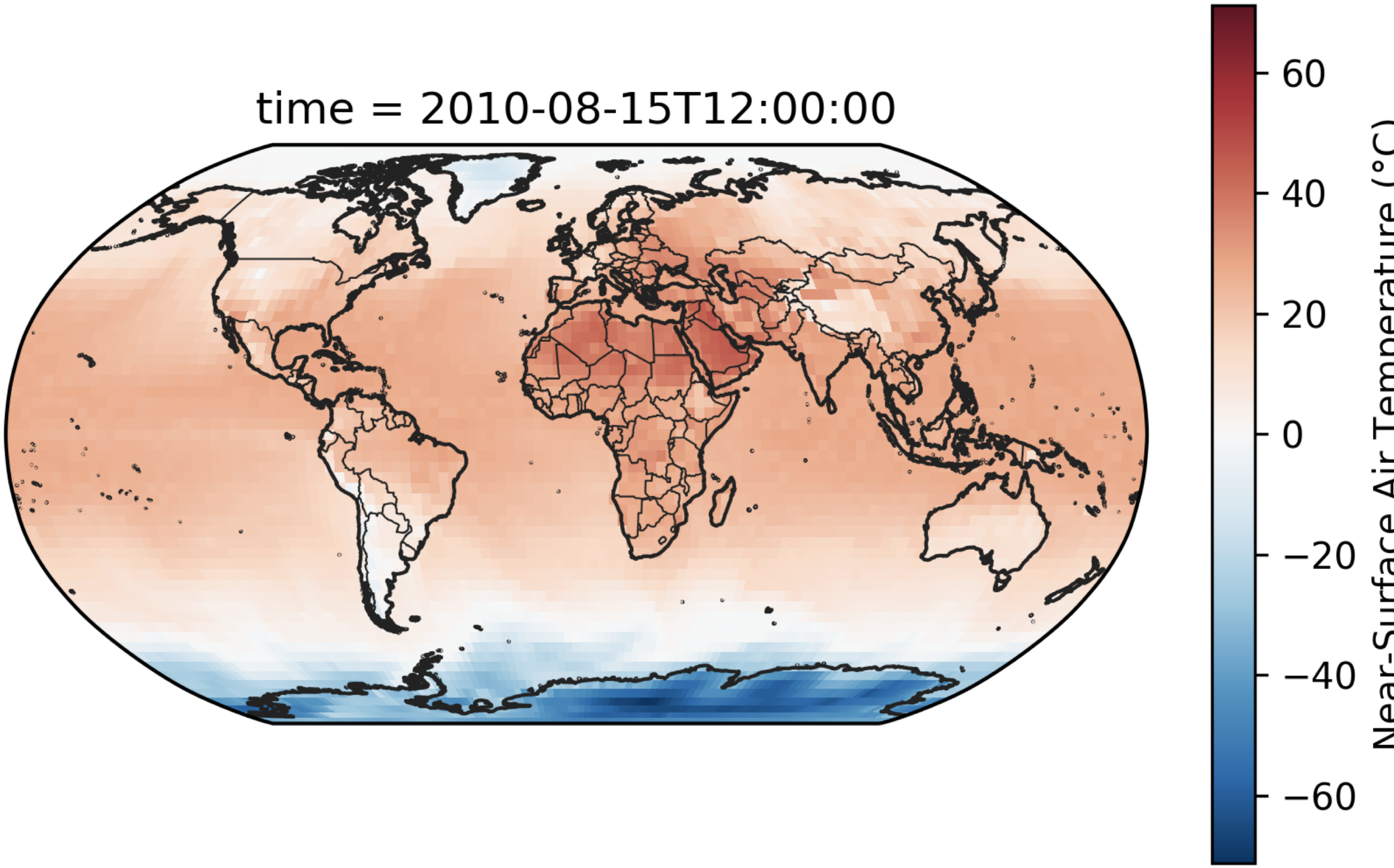


Figure: Schematic of 4DVAR approach 2 (schematic taken from ECMWF website)

Note fluxes must be derived from nonlinear model integration (or short forecast).

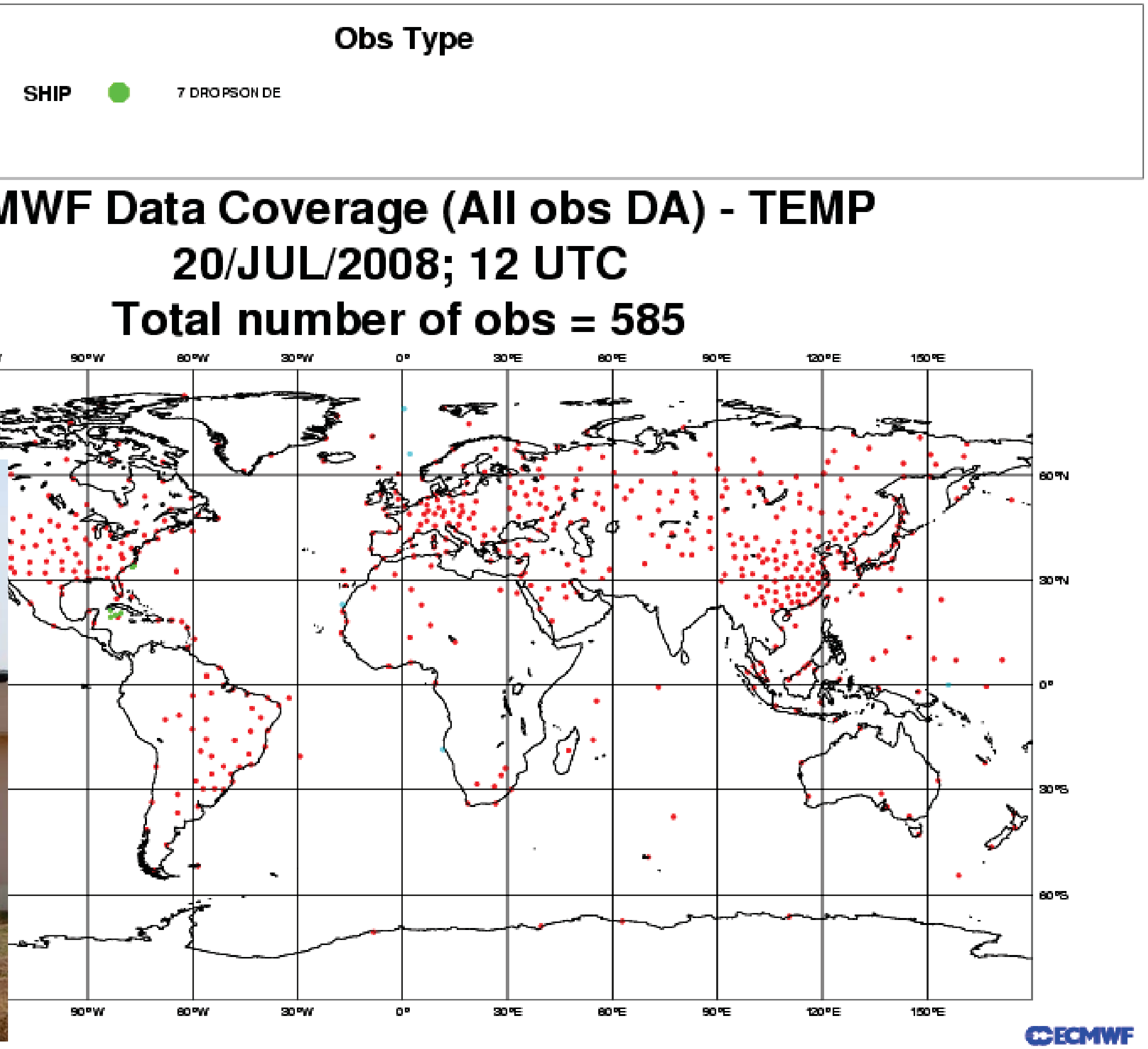
Example: ERA5 surface temperature from C3S toolbox



Let's take a look at the monitoring

https://www.ecmwf.int/en/forecasts/charts/monitoring/dcover?facets=undefined&time=2019052406,0,2019052406&obs=synop-ship&Flag=all

DATA USED: T,q,u,v – humidity to 300 or 100hPa

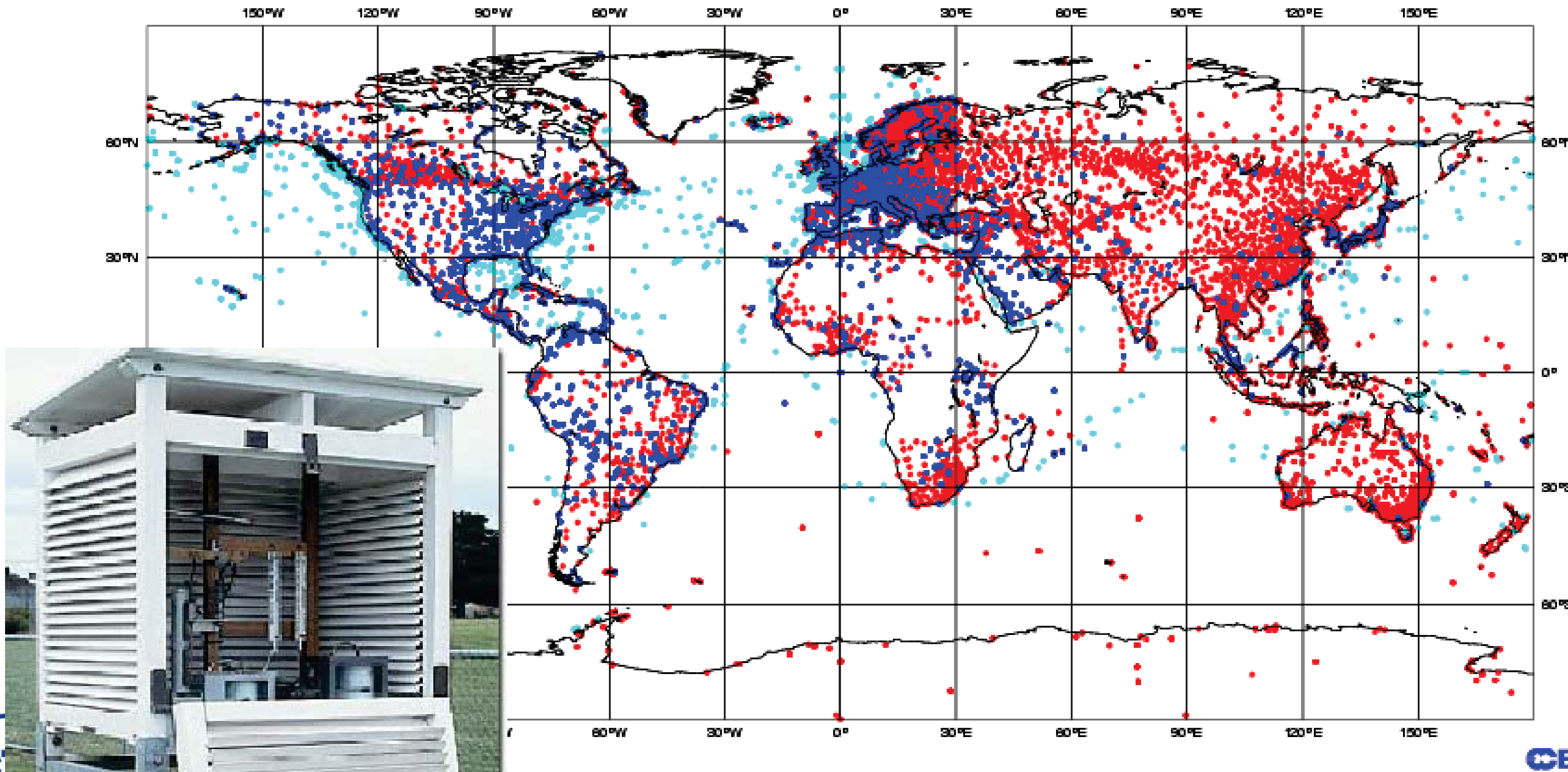


DATA USED: Pressure, humidity during day
SYNOP T,q also used for soil moisture analysis

Obs Type

● 17092 SYNOP ● 2513 SHIP ● 12011 METAR

ECMWF Data Coverage (All obs DA) - SYNOP/SHIP
20/JUL/2008; 12 UTC
Total number of obs = 31616



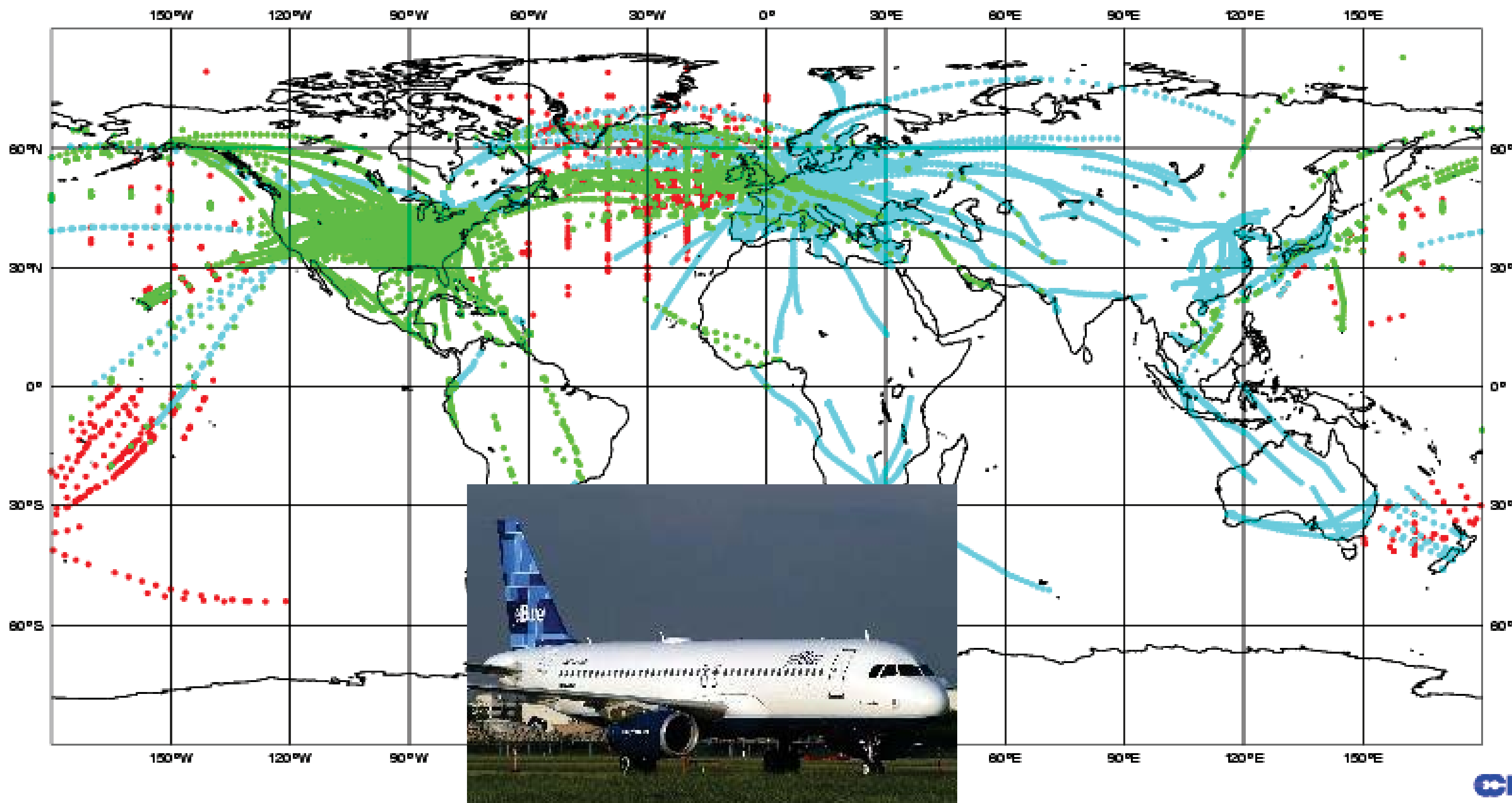
ECMWF

DATA USED: Temperature, winds
(mozaic humidity research product)

Obs Type

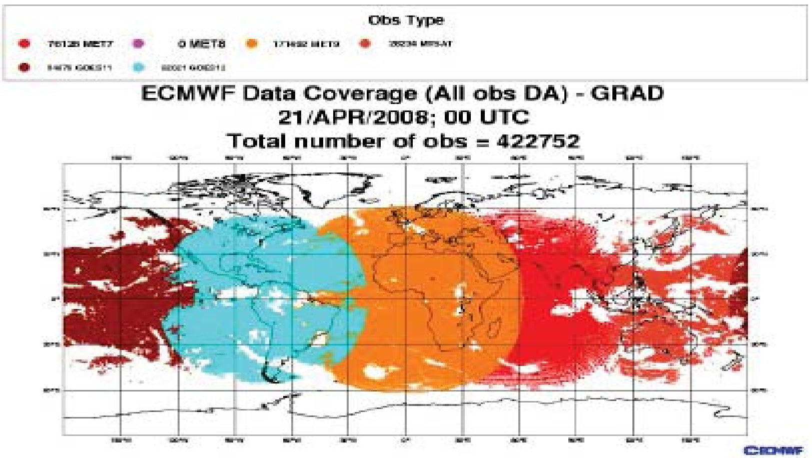
● 18035 ACARS

ECMWF Data Coverage (All obs DA) - AIRCRAFT
20/JUL/2008; 12 UTC
Total number of obs = 50089



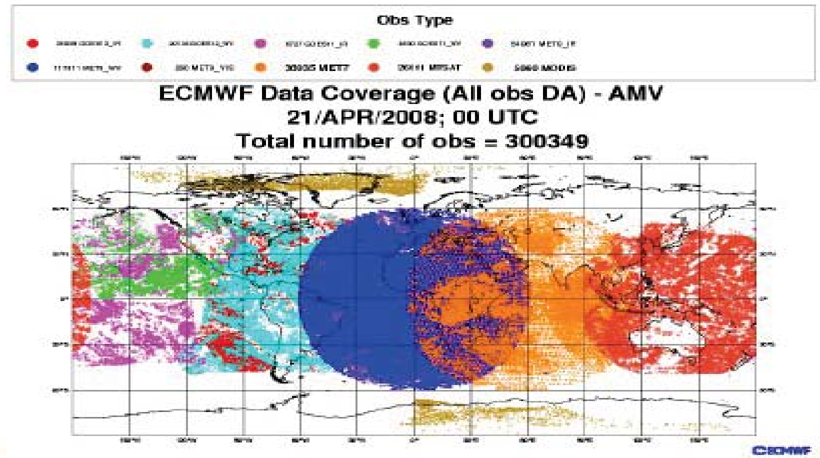
ECMWF

Clear-sky radiances



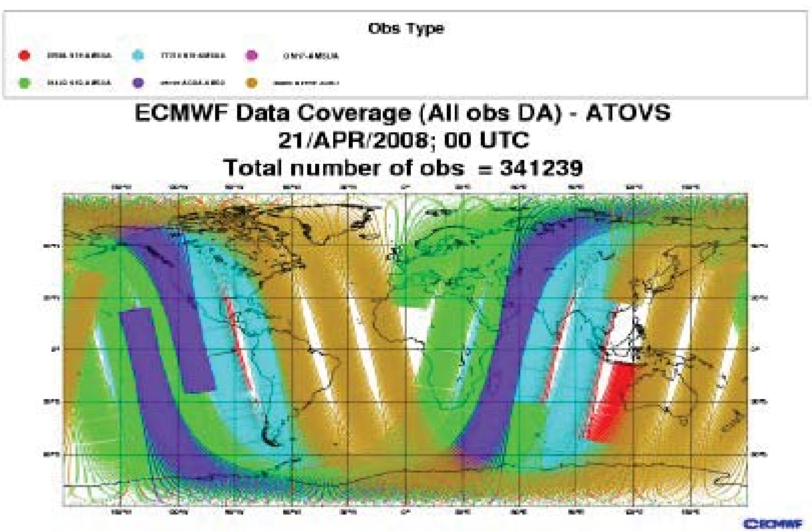
GOES-W GOES-E Met-9 Met-7 MTSAT-1R

Atmospheric Motion Vectors

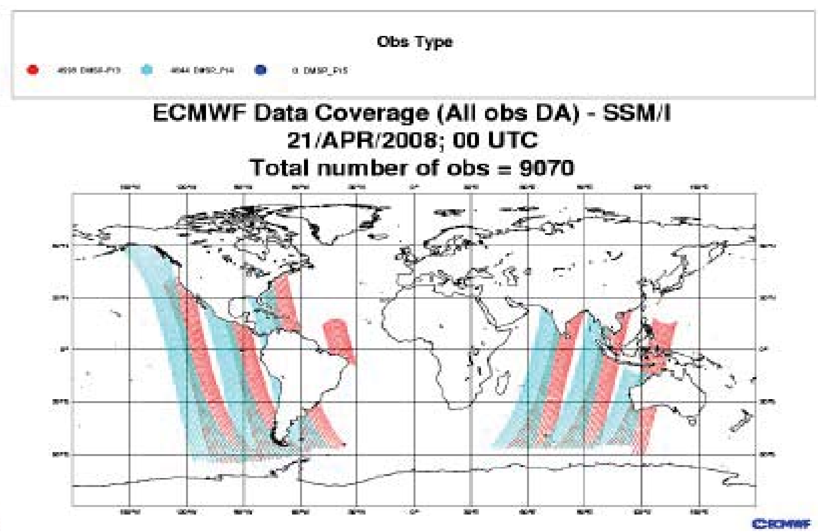


GOES-W GOES Met-9 Met-7 MTSAT-1R

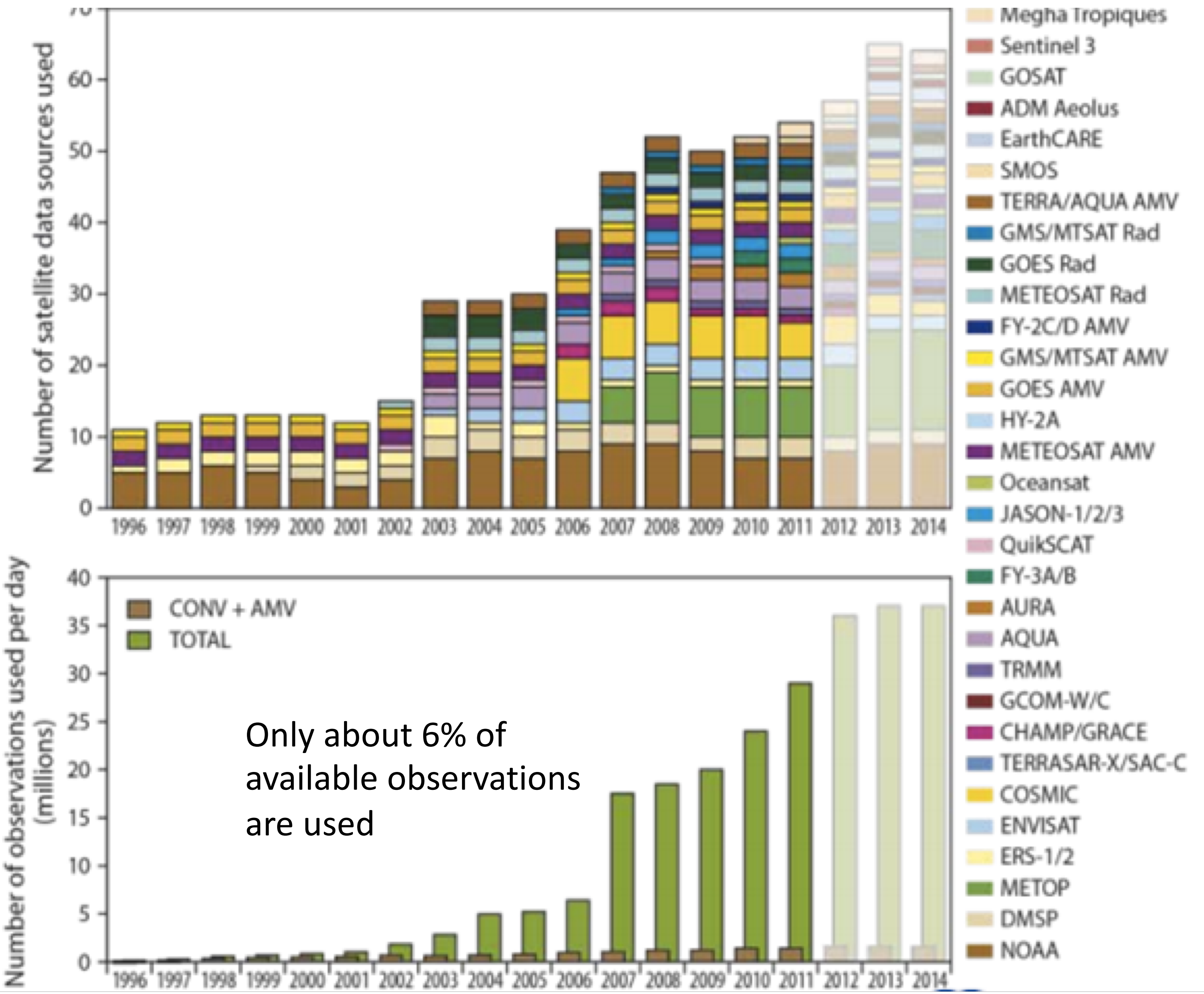
AMSU-A



SSM/I



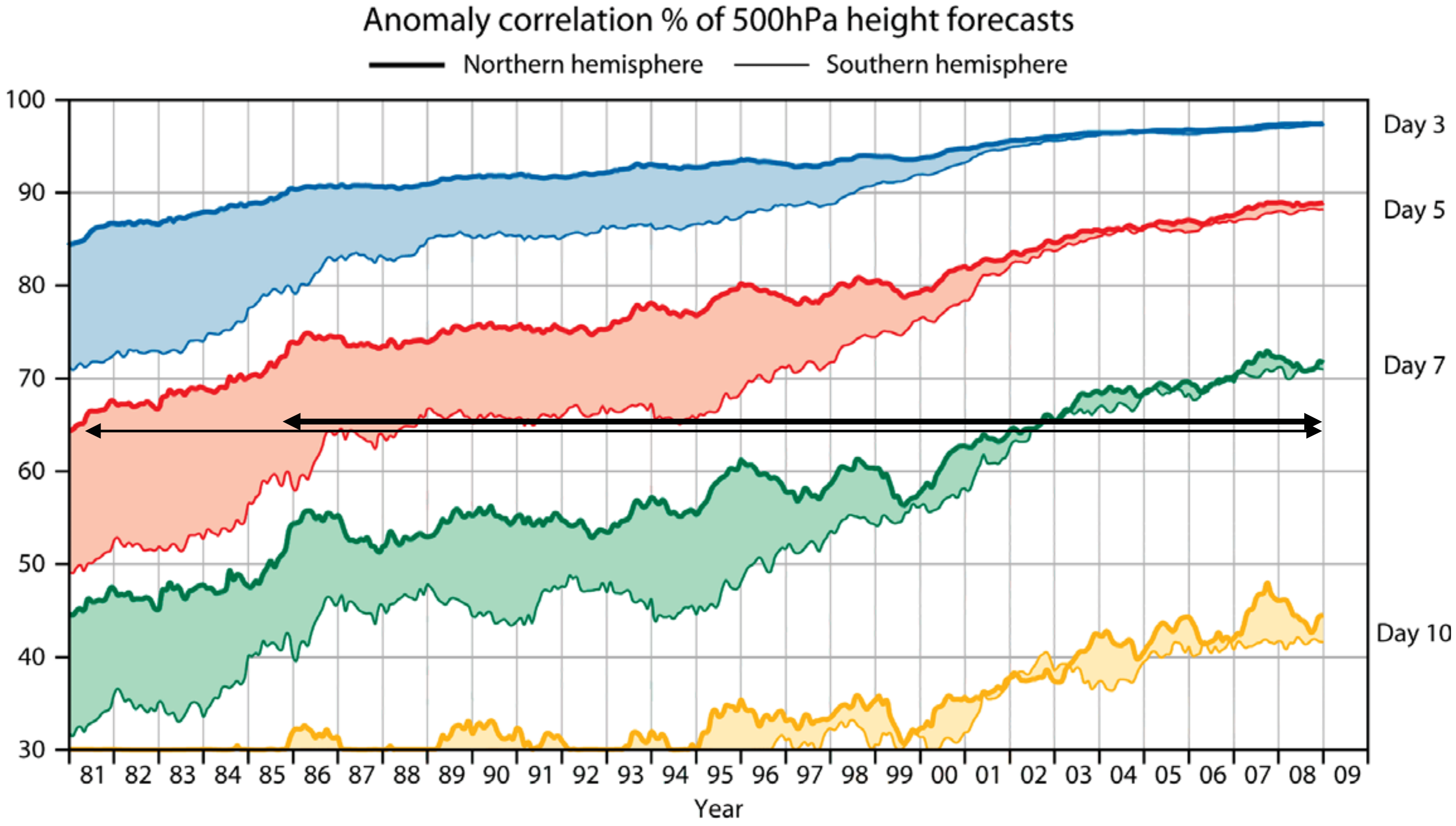
Satellite data usage at ECMWF



Only about 6% of available observations are used

Evolution of ECMWF scores over NH and SH for Z500

- Over NH (SH) a day-7 single forecast of the upper-air atmospheric flow has the same accuracy as a day-5 in 1985 (day-3 in 1981).
- Note that Satellite data now implies equally good FC in NH and SH



Some common misconceptions

- Very little information concerning clouds or precipitation is directly assimilated into the model
- Clouds in the analysis are a model product from the model physics, their location/properties determined by temperature, humidity and dynamics.
- Thus the parameters most important for impacts modelling (e.g. esp. temperature and precipitation) are all influenced by the model physics even in the analysis

But what is REanalysis?

- Operational forecasting systems change their systems 3 or 4 times a year
  - New observation sources to be incorporated
  - Improvements to the physics in the forecast models
  - Improvements to the data assimilation techniques.
- This means that the analyses are not "coherent" in time
  - e.g. Could a temperature trend be due to changes in data and/or assimilation system
- One way to improve the coherency in reanalysis: The same system is run for all past dates.

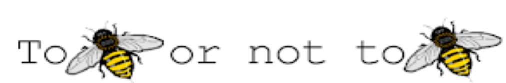
To analysis or reanalysis – that is the question?

Analysis

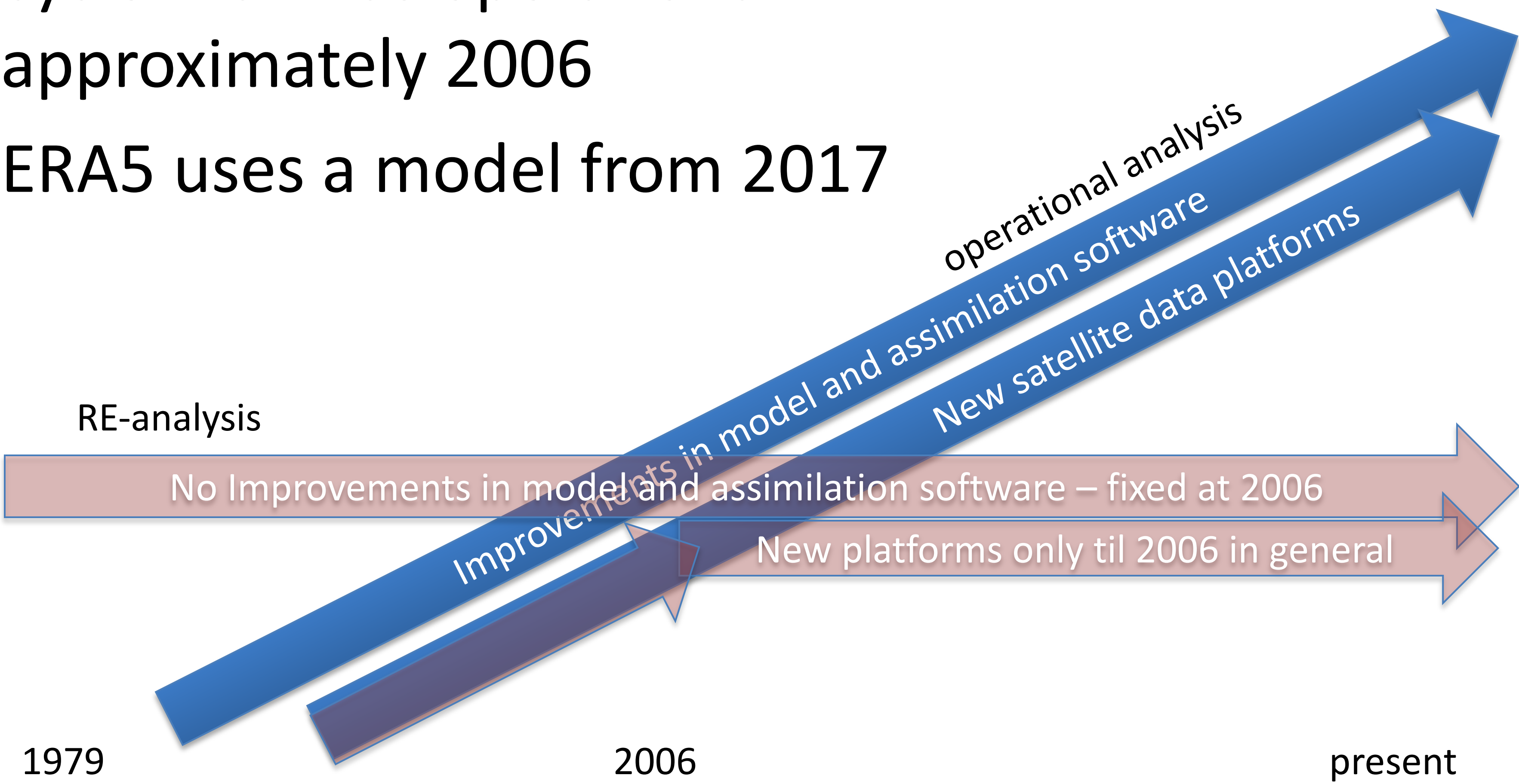
- Latest operational system
- High resolution
- Latest observation suite
- Model and observations change over time
- Not easily available
- Ideal for recent case study

Reanalysis (e.g. ERAI)

- Using same model system, rerun for long period
- More continuity, although observations change over time
- Low resolution
- Obsolete model (ERAI from 10 years ago)
- Ideal for long term study

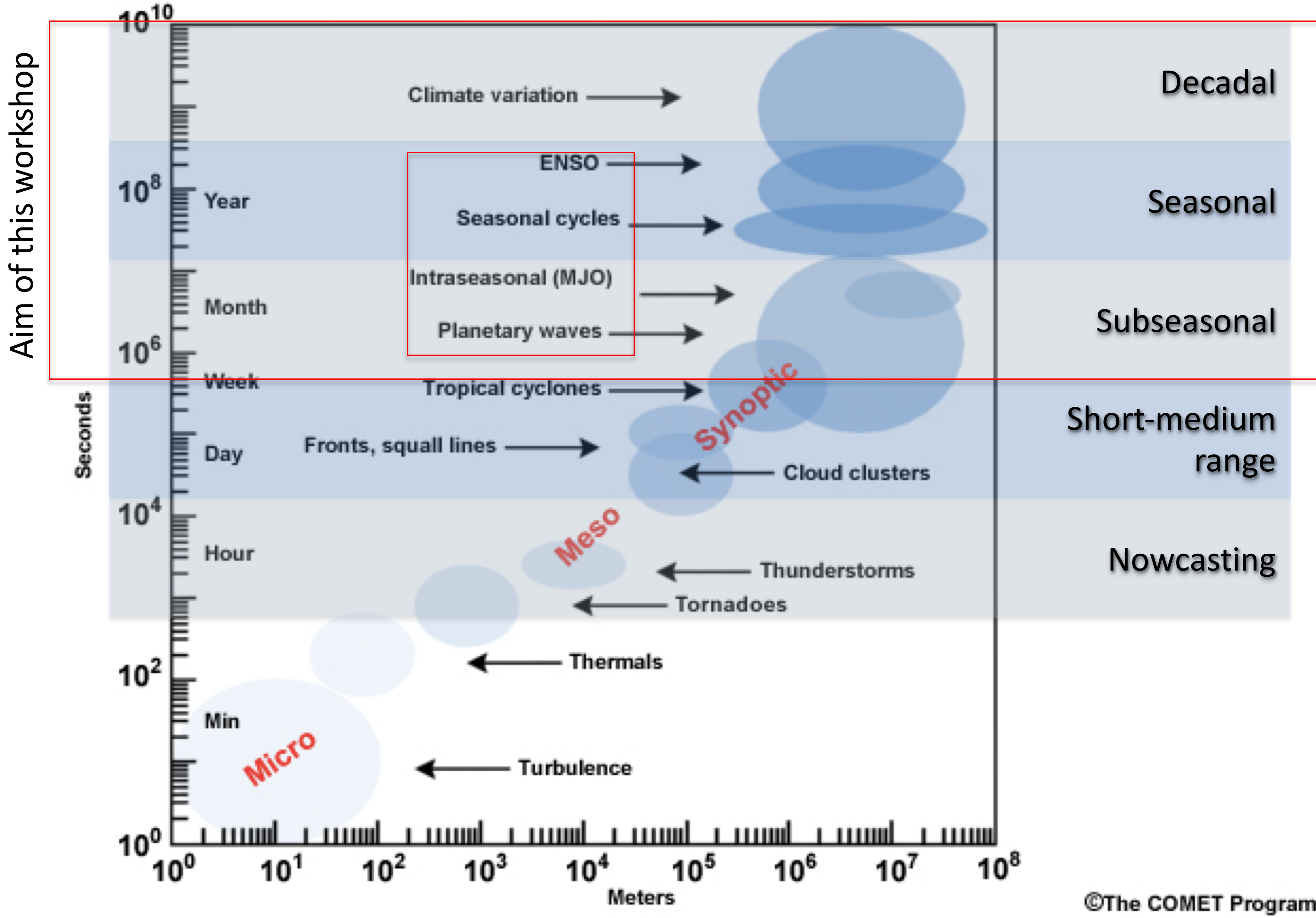


- Reanalysis of ERA-40 uses a model cycle that was operational in 2000
- Reanalysis of ERA-Interim uses a model cycle that was operational in approximately 2006
- ERA5 uses a model from 2017

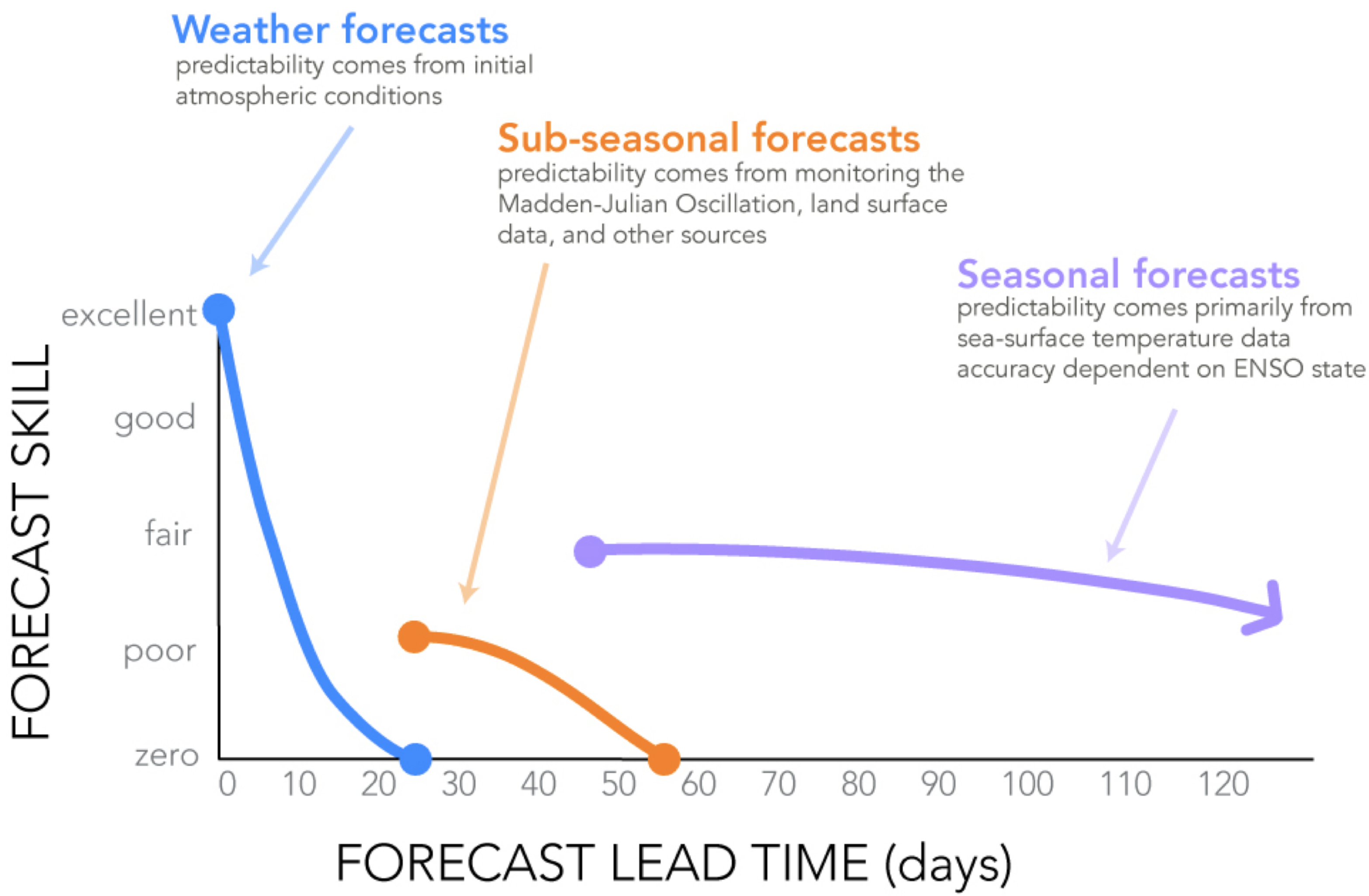


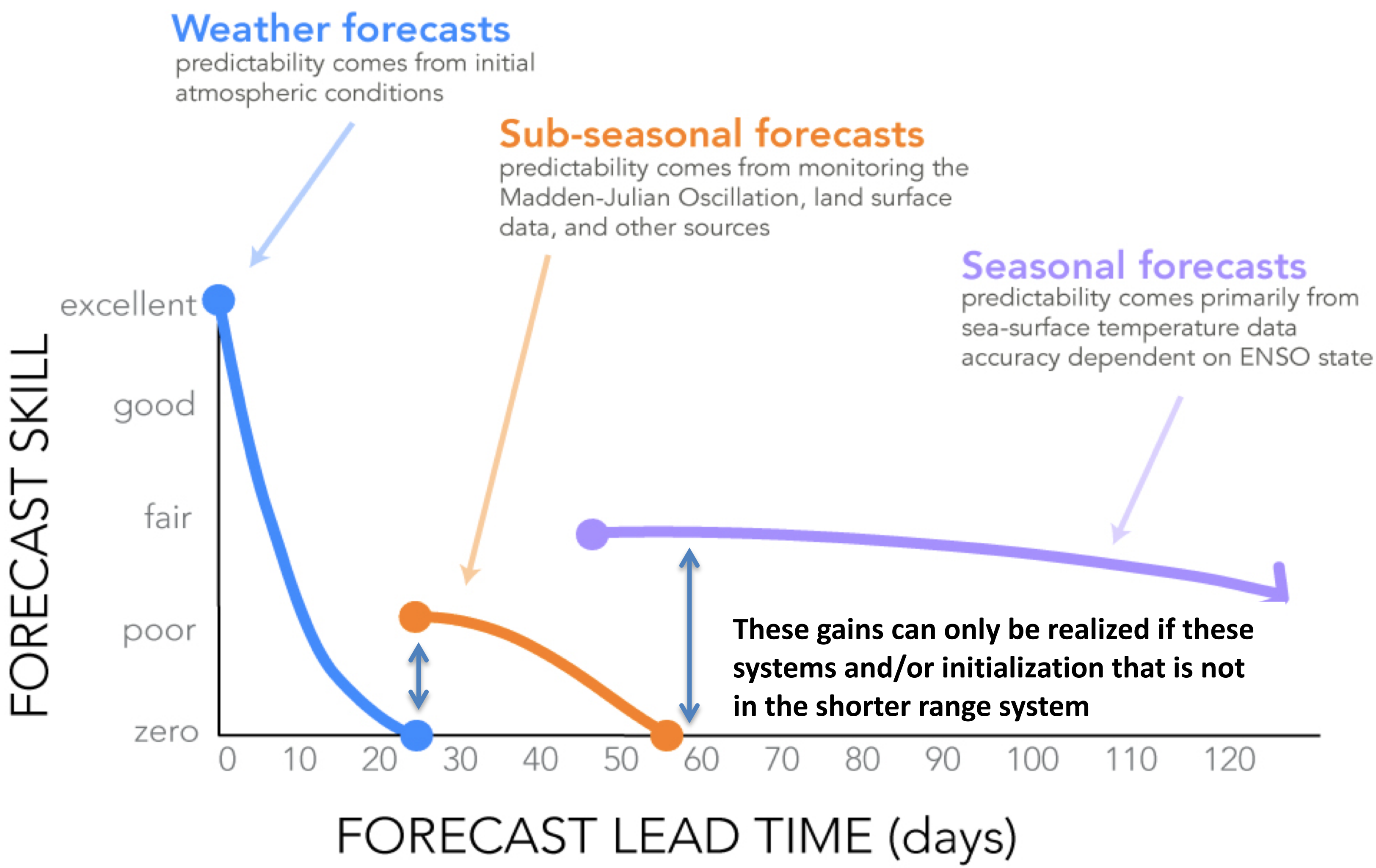
ERA5 – A product of EU Copernicus programme

	ERA-Interim	ERA5
Period	1979 – present	1979 – present
Production period	August 2006 – end 2018	Jan 2016 – end 2017, then continued in near real-time
Assimilation system	IFS Cycle 31r2	IFS Cycle 41r2
Model input	As in operations (inconsistent SST)	Appropriate for climate (e.g. CMIP5 greenhouse gases, volcanic eruptions, SST and sea-ice cover)
Spatial resolution	79 km globally, 60 levels to 0.1 hPa	31 km globally, 137 levels to 0.01 hPa
Uncertainty estimates	None	From a 10-member Ensemble of Data Assimilations (EDA) at 63 km resolution
Output frequency	6-hourly analysis, 3-hourly forecast fields	Hourly analysis and forecast fields, 3-hourly for the EDA
Input observations	As in ERA-40 and from Global Telecommunication System	In addition, various newly reprocessed datasets and recent instruments that could not be ingested in ERA-Interim
Variational bias scheme	Satellite radiances	Also ozone, aircraft and surface pressure data
Satellite data	RTTOV-7, clear-sky	RTTOV-11, all-sky for various components
Additional innovations		Long-term evolution of CO_2 in RTTOV, cell-pressure correction SSU, improved bias correction for radiosondes, EDA perturbations for sea-ice cover

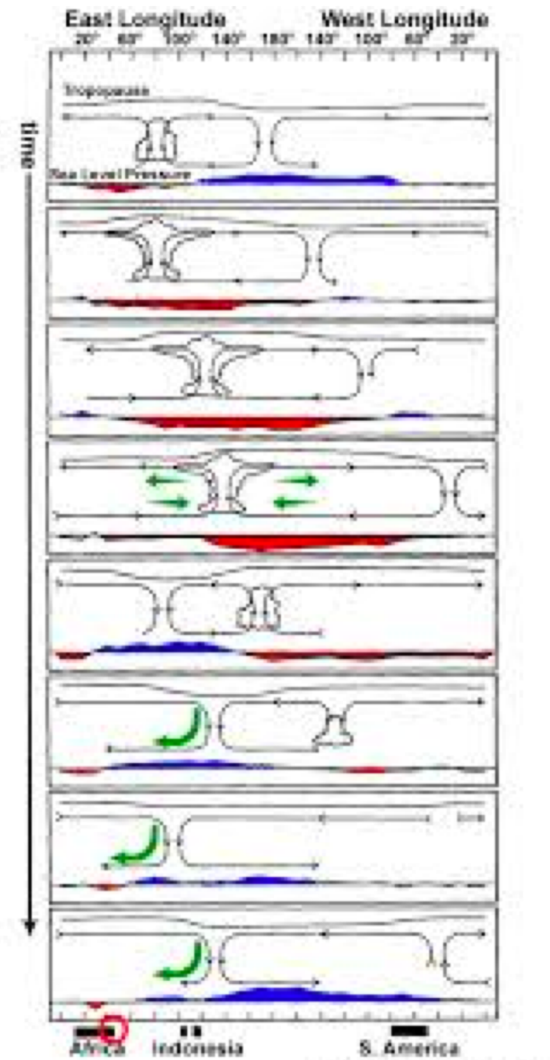

Aim of this workshop
Climate variation
ENSO
Seasonal cycles
Intraseasonal (MJO)
Planetary waves
Tropical cyclones
Fronts, squall lines
Cloud clusters
Thunderstorms
Tornadoes
Thermals
Turbulence
Synoptic
Meso
Micro
Year
Month
Week
Day
Hour
Min
Seconds
Meters
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}
10^{10}
Decadal
Seasonal
Subseasonal
Short-medium range
Nowcasting
©The COMET Program

processes and skill...

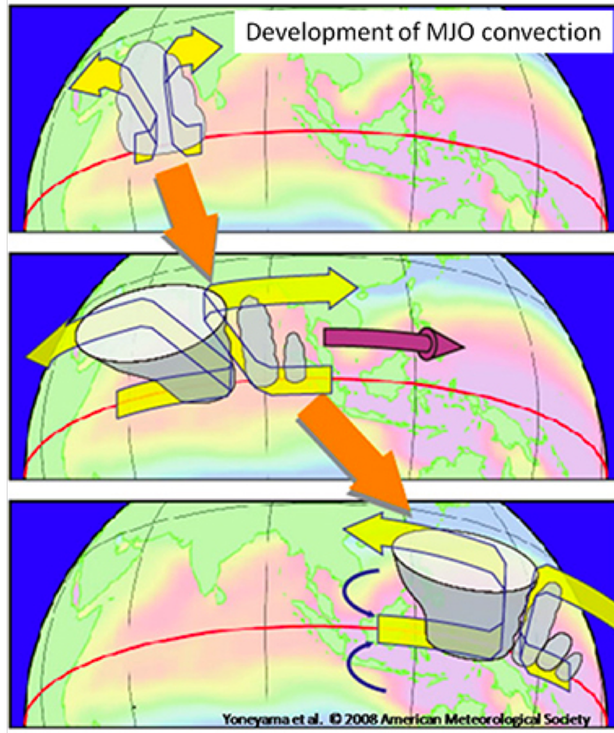



Weather forecasts
predictability comes from initial atmospheric conditions
Sub-seasonal forecasts
predictability comes from monitoring the Madden-Julian Oscillation, land surface data, and other sources
Seasonal forecasts
predictability comes primarily from sea-surface temperature data accuracy dependent on ENSO state
excellent
good
fair
poor
zero
FORECAST SKILL
0
10
20
30
40
50
60
70
80
90
100
110
120
FORECAST LEAD TIME (days)
These gains can only be realized if these systems and/or initialization that is not in the shorter range system

The Madden-Juilian Oscilliation



Madden and Julian, 1972

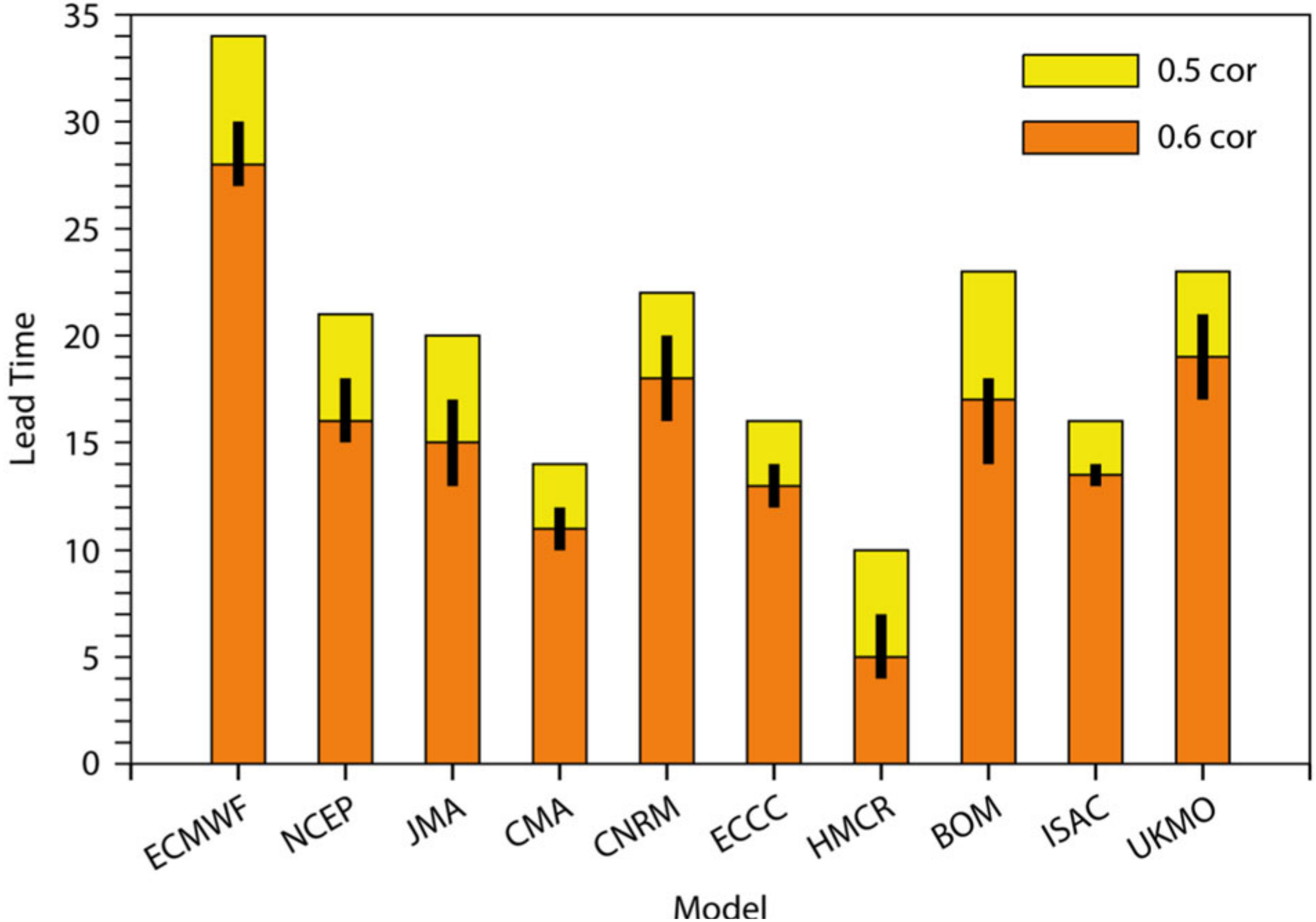


Cumulonimbi aggregates into an envelope of cloud clusters in the western equatorial Indian ocean

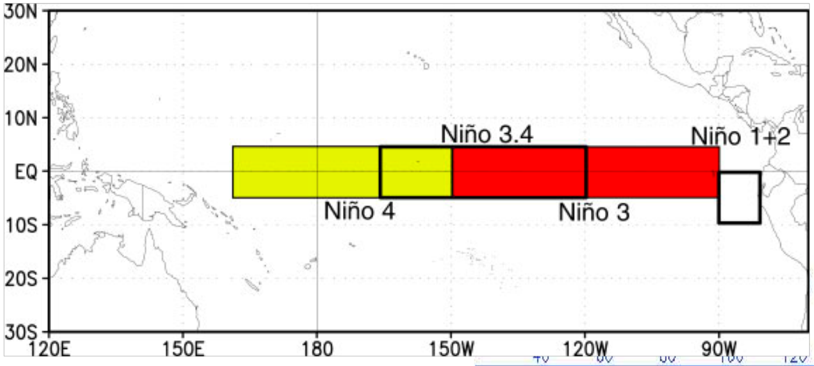
The envelope of cloud clusters migrate eastward to the western Pacific ocean at approximately 5 m/s

Cause heavy rain and generate atmospheric vortices
→ Floods, Typhoon initiations

This is important as the MJO skill has been improving in models



Seasonal prediction: ENSO



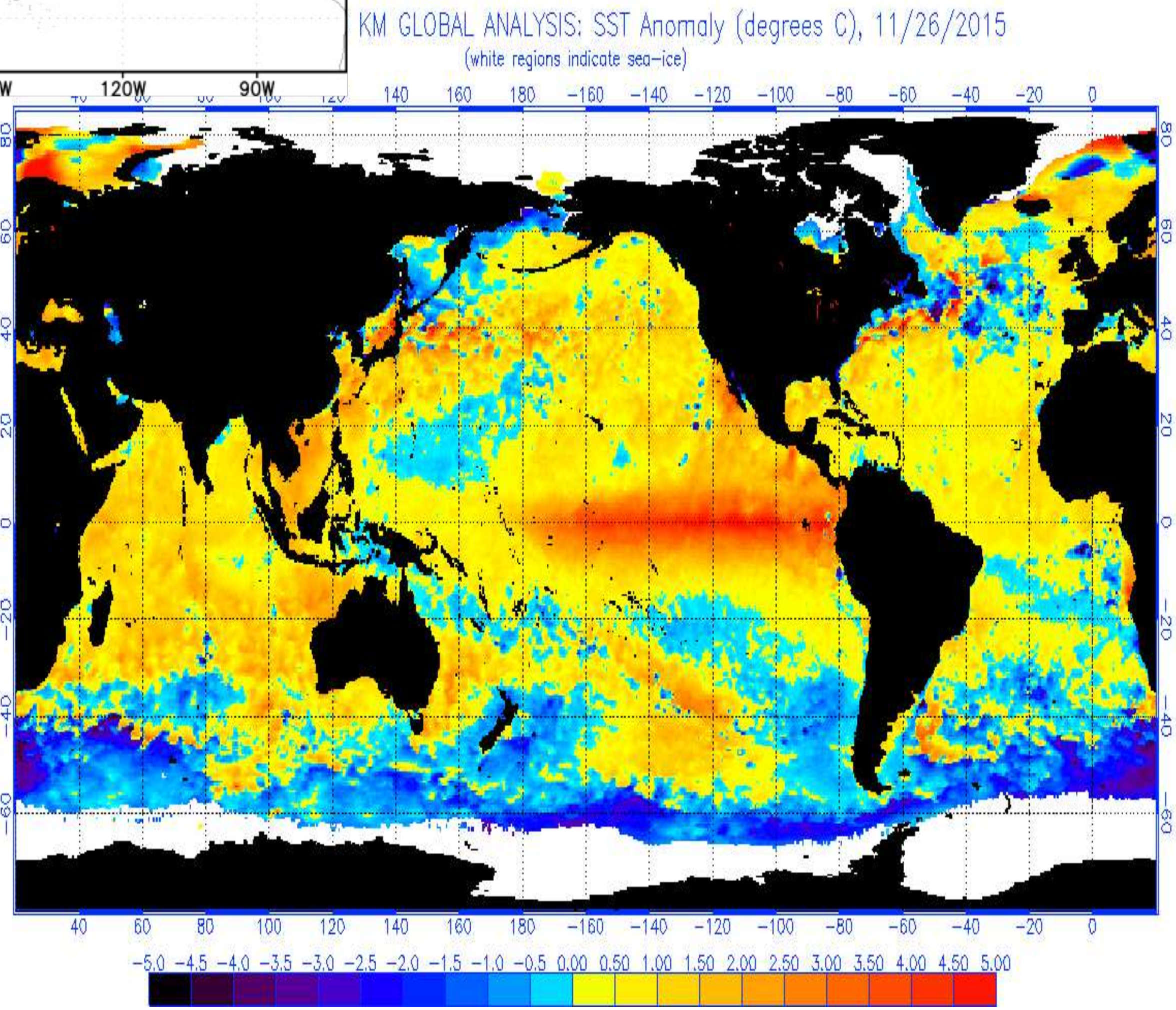
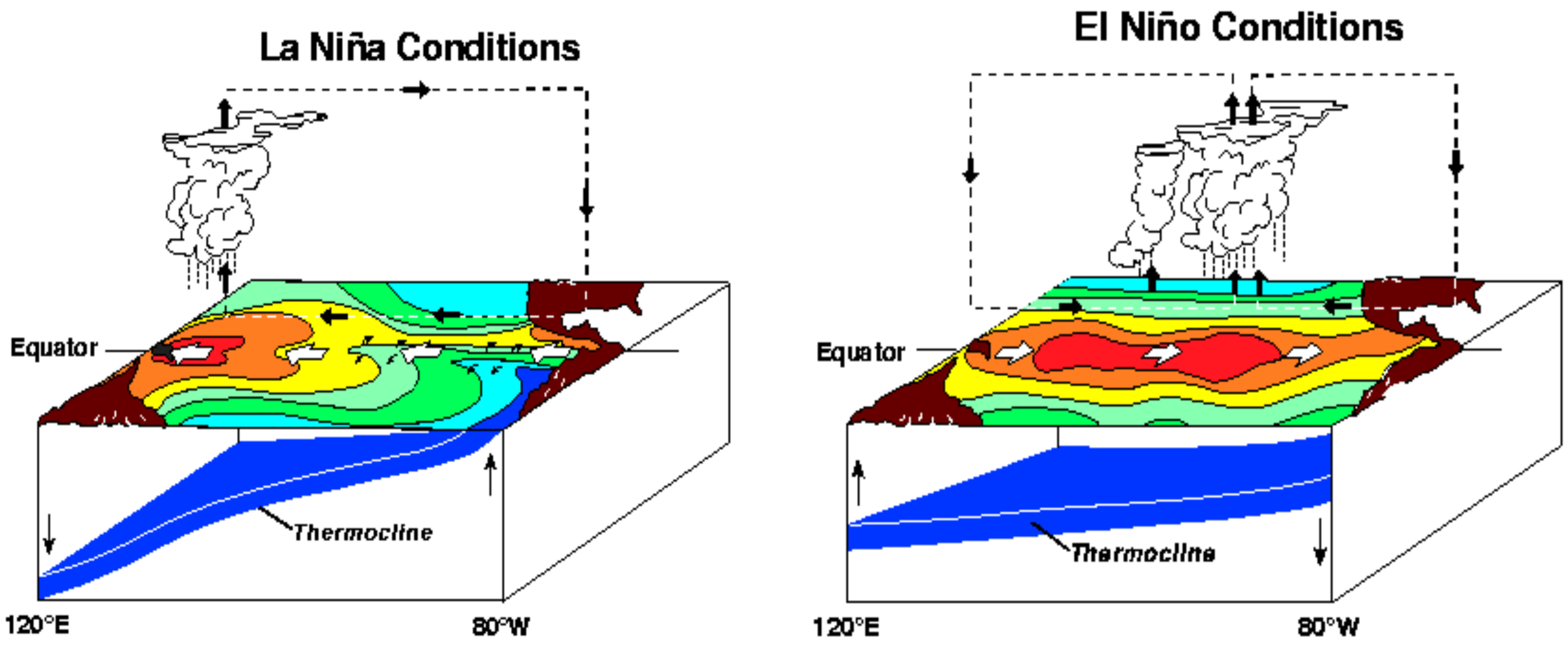


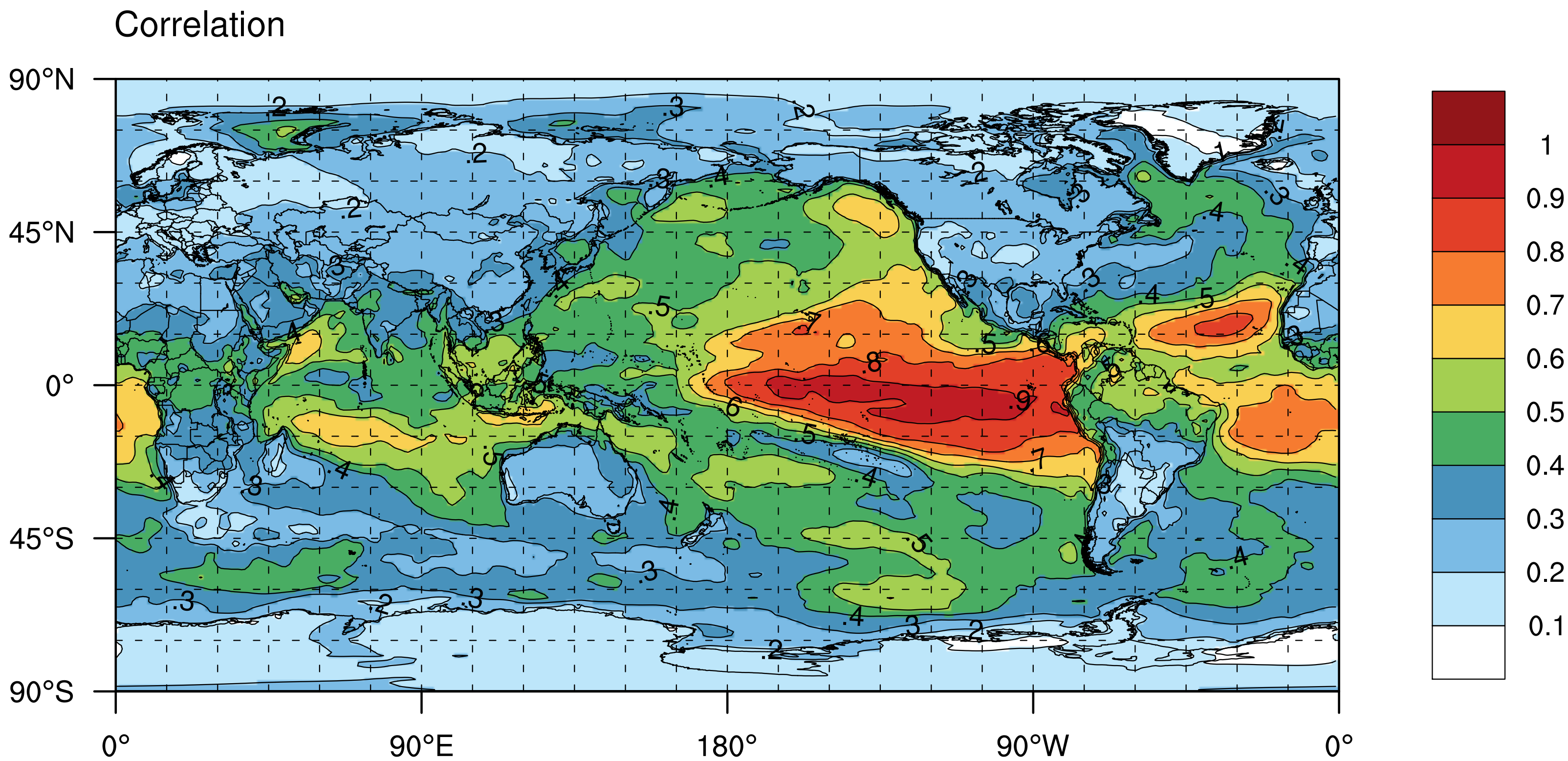
Figure 13: SST anomaly on 26. Nov 2015. Source: http://www.ospo.noaa.gov/data/sst/anomaly/2015/anomnight.11.26.2015.gif.

La Nino and El Nino conditions

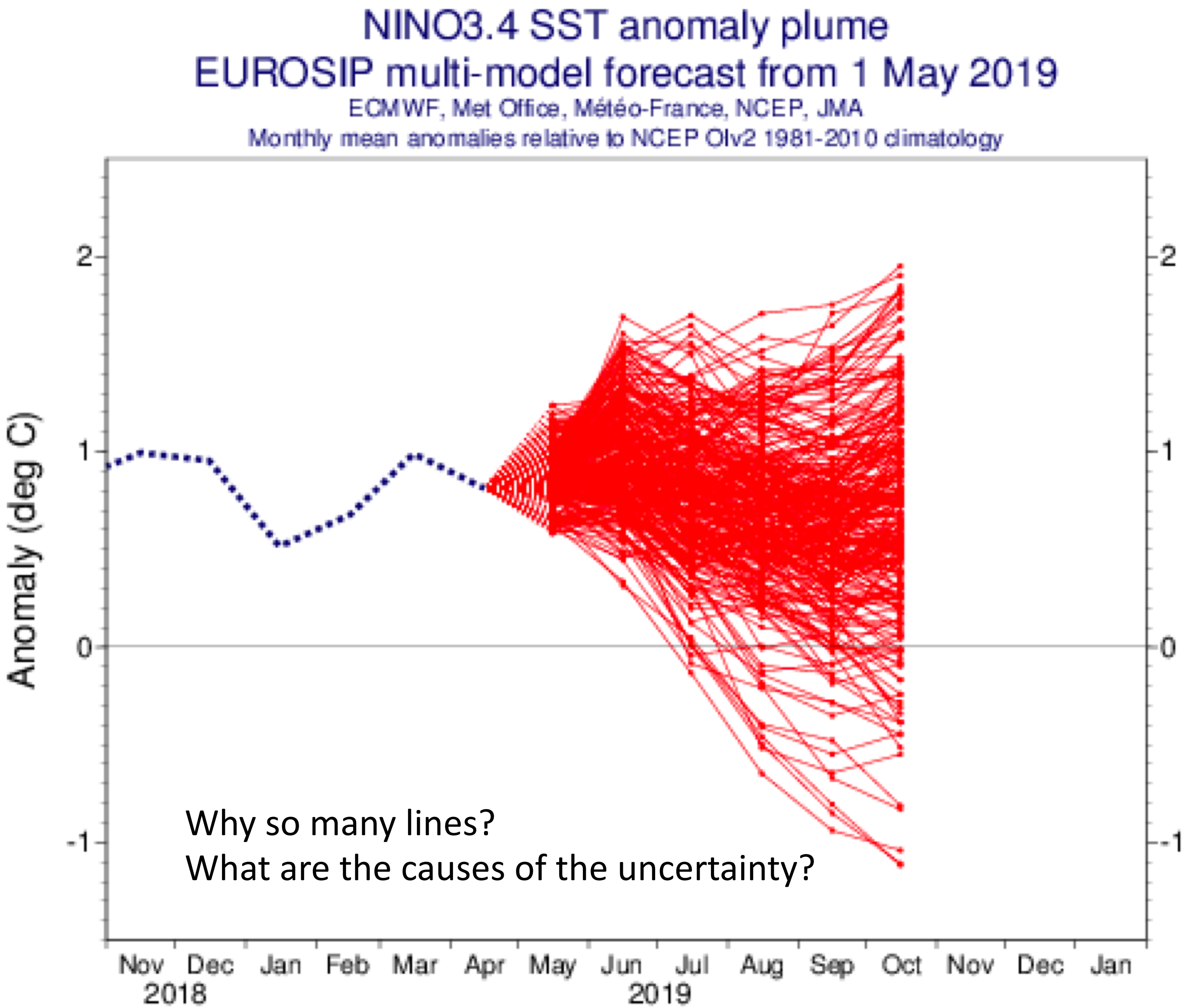


Thermocline deepens to the as as a result of the Eastward propagating Ocean Kelvin wave

S2S week 3-4 correlation
high skill over ENSO region
<u>But does it beat persistence</u>?

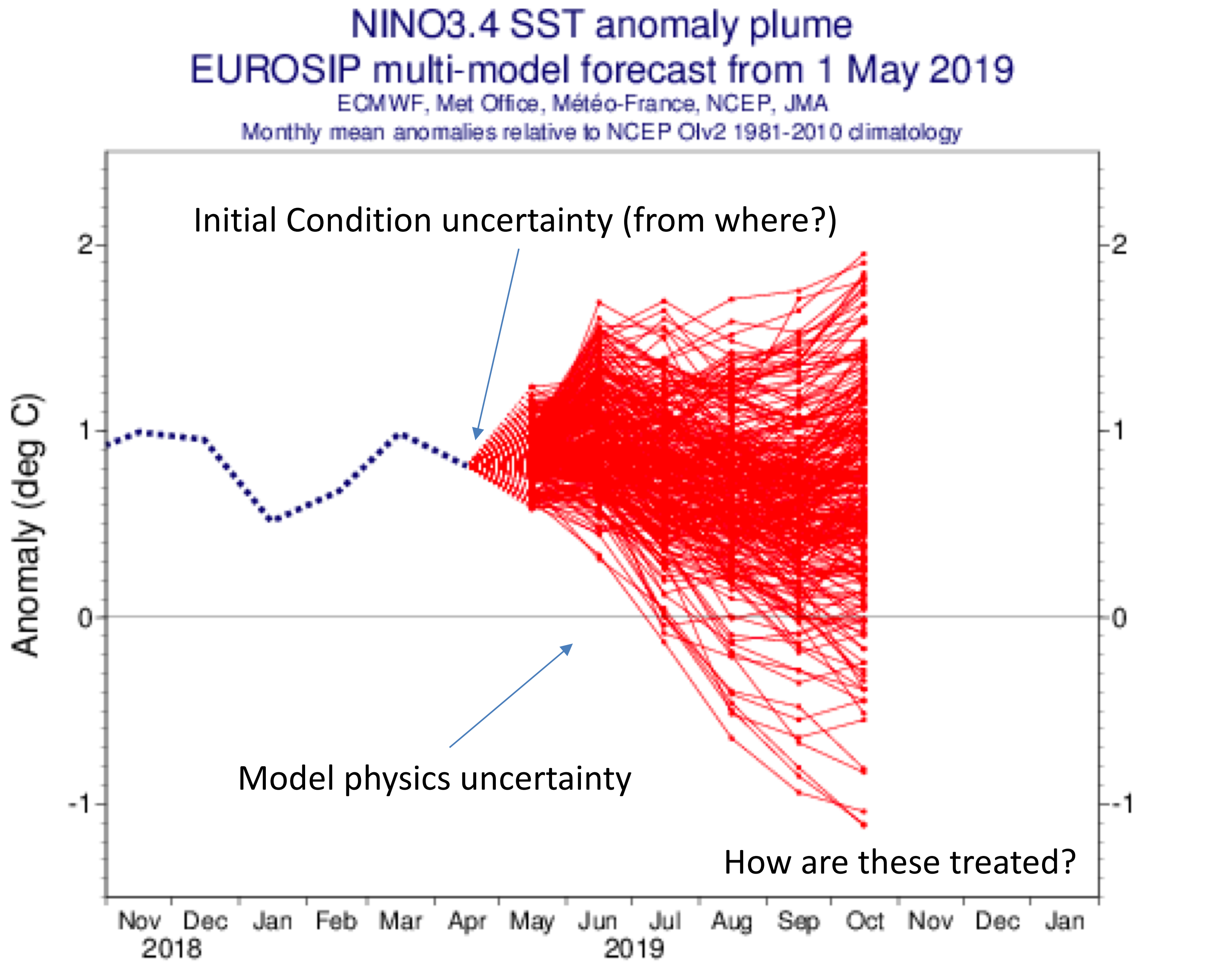


Seasonal Forecasting systems Eurosip

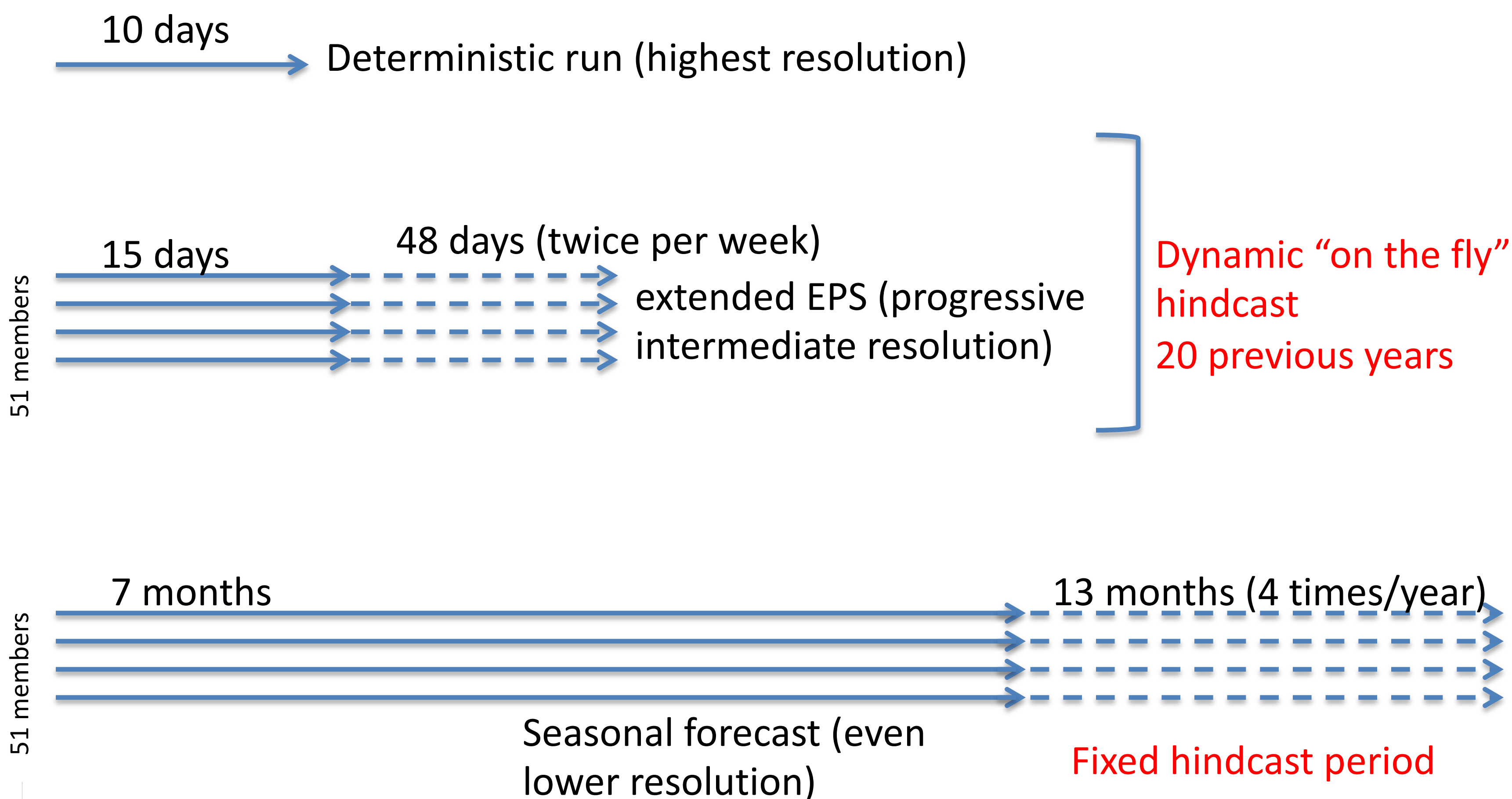


Why so many lines?
What are the causes of the uncertainty?

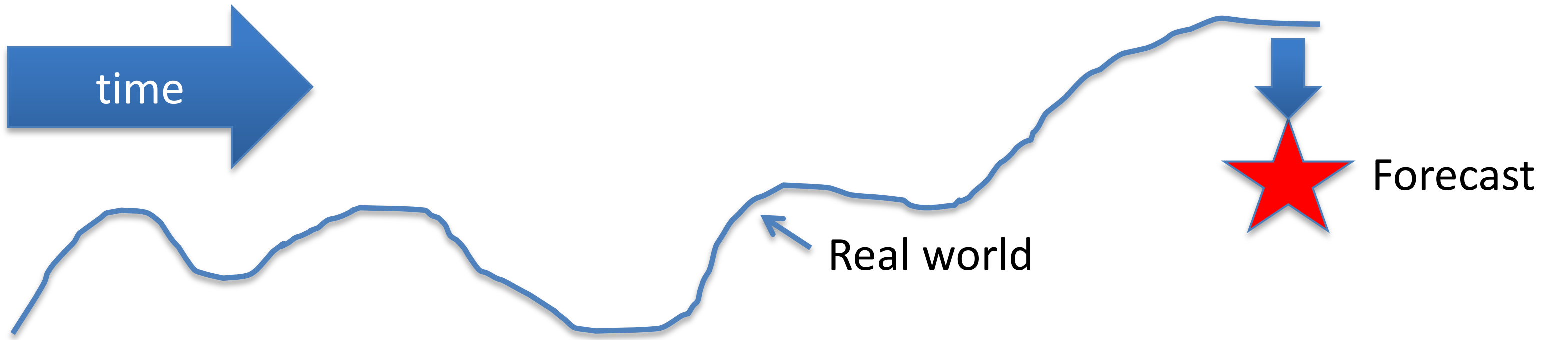
Seasonal Forecasting systems Eurosip



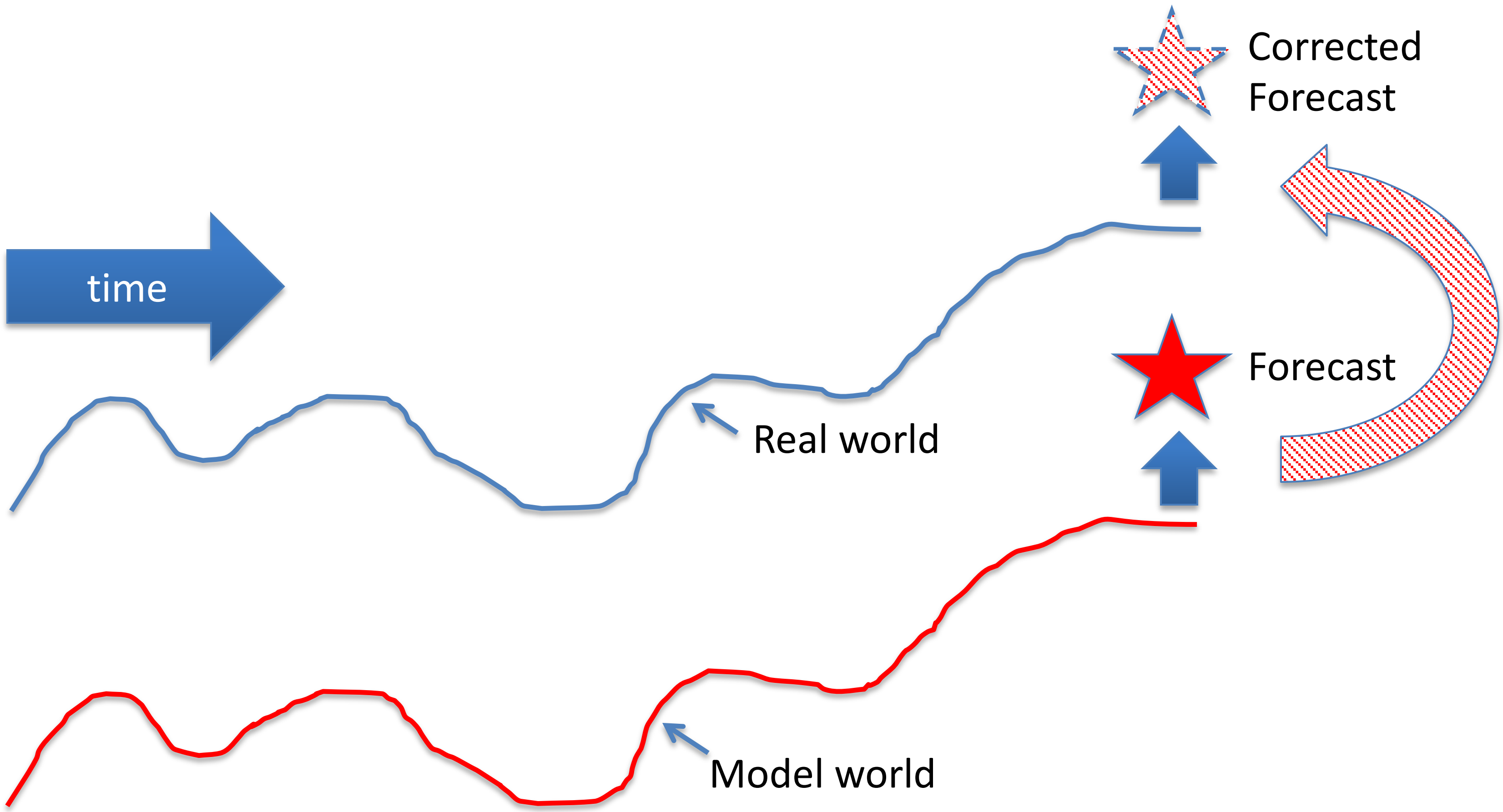
An introduction to the ECMWF framework



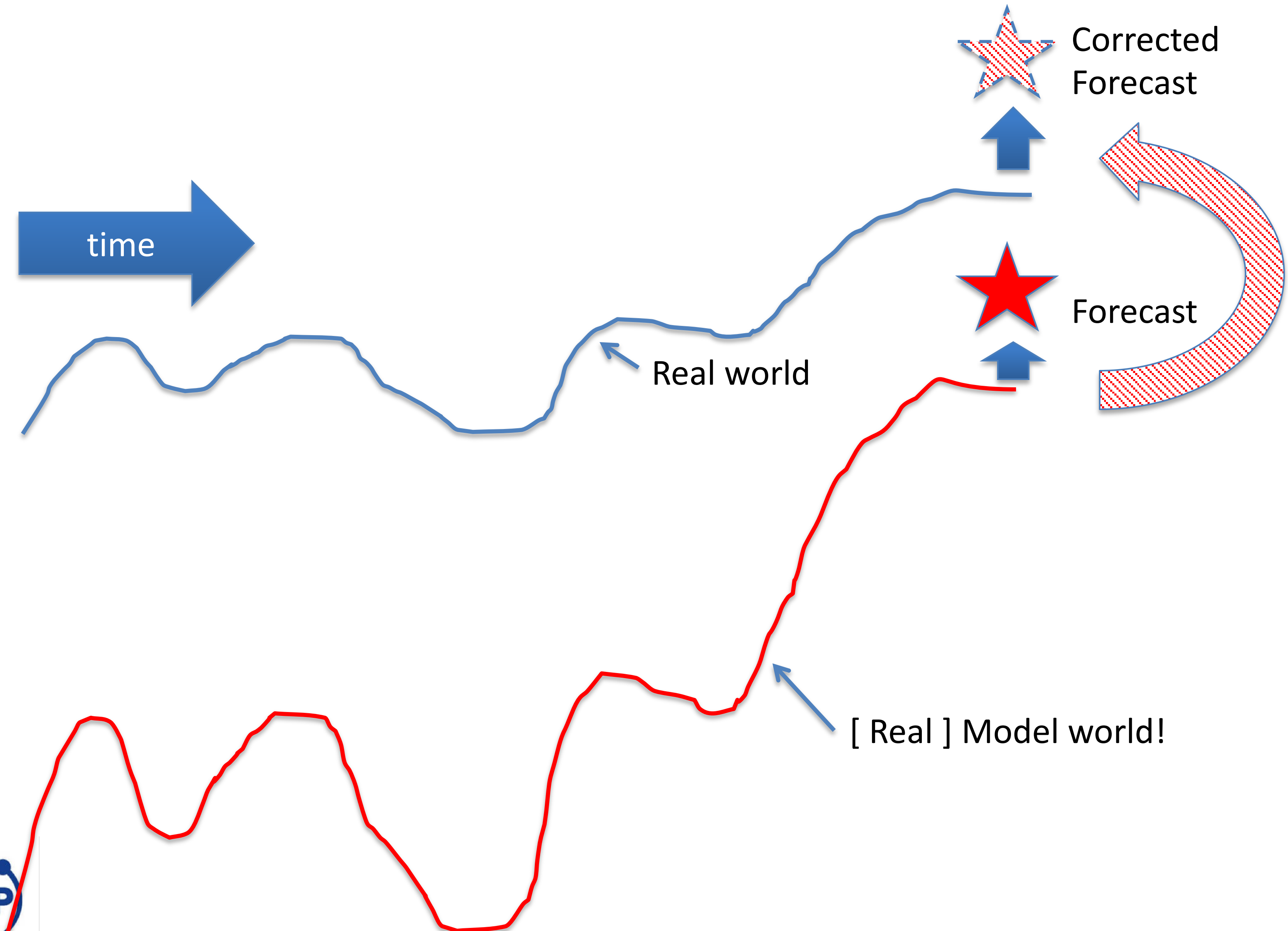
Why do we need the hindcast suite?



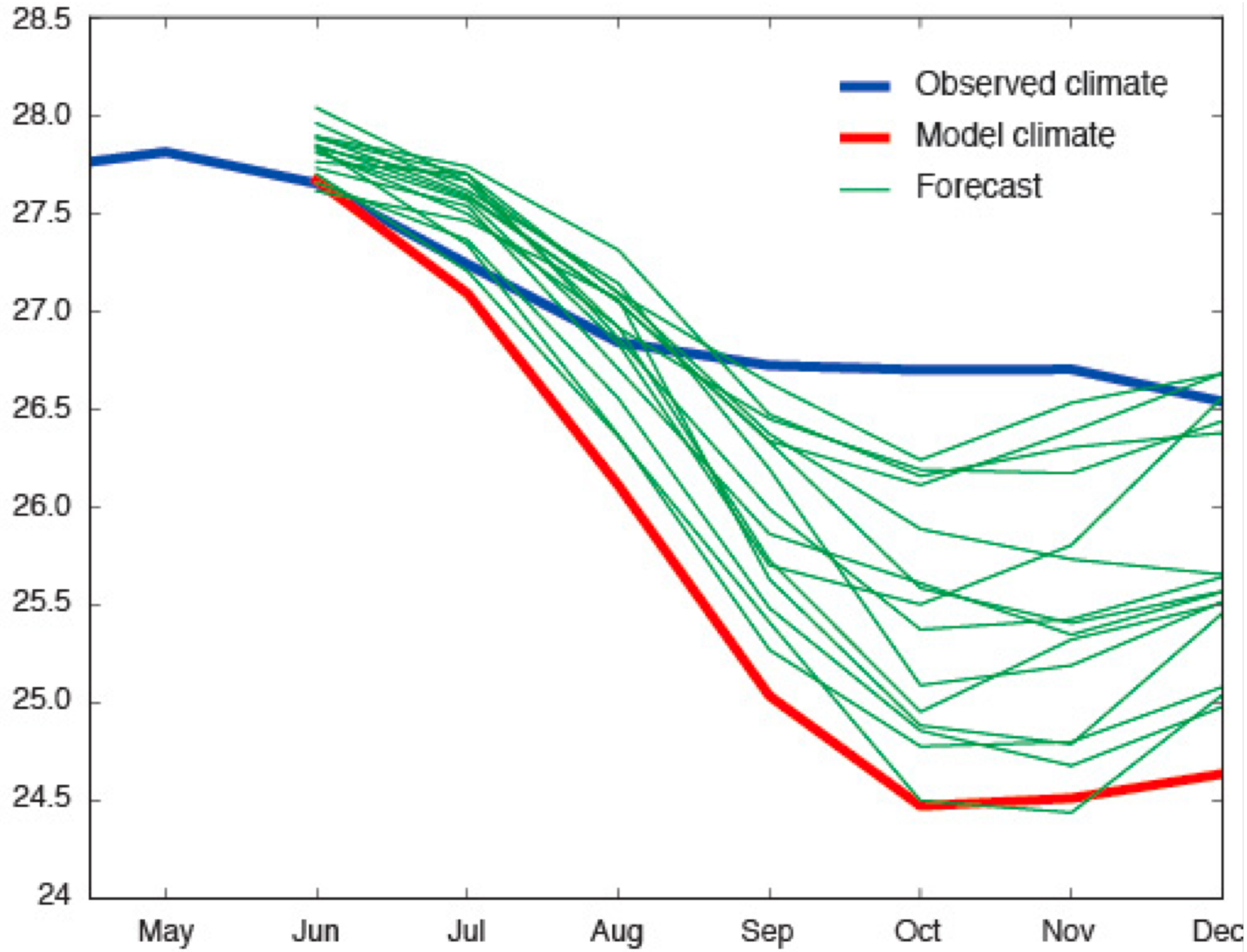
Why do we need the hindcast suite?



Why do we need the hindcast suite?

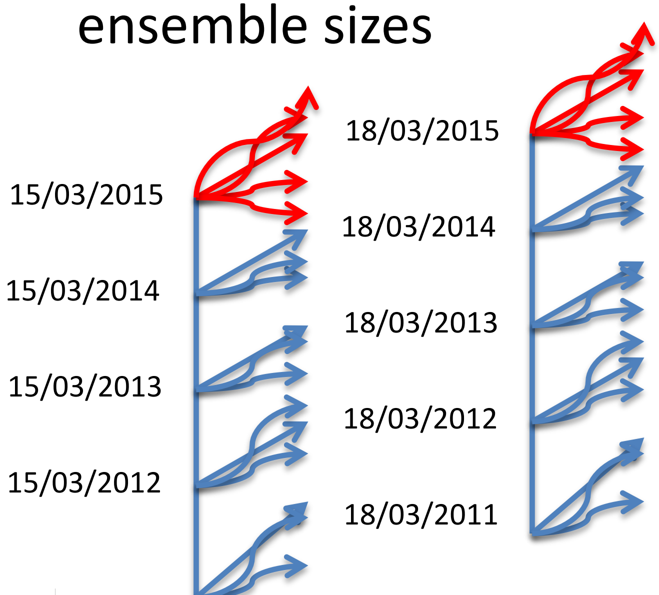


Example for temperature forecasts from SYS5

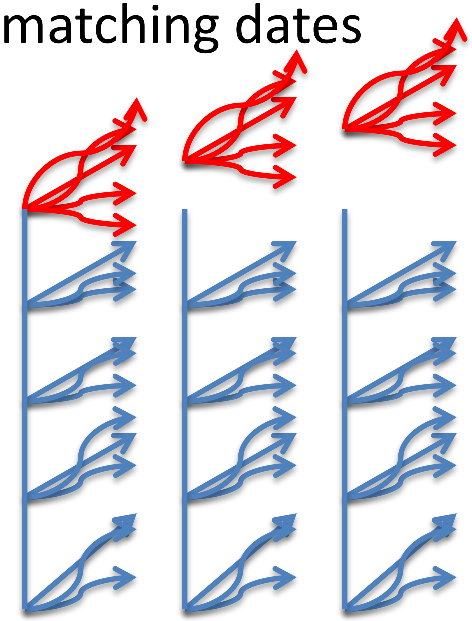


Hindcast Strategies

- "On the fly" – Each forecast is accompanied by a set of hindcasts starting on the same date for the previous N years
  - GOOD: same model version and set up
  - GOOD: Always same start date
  - BAD: Expensive to run, smaller ensemble sizes

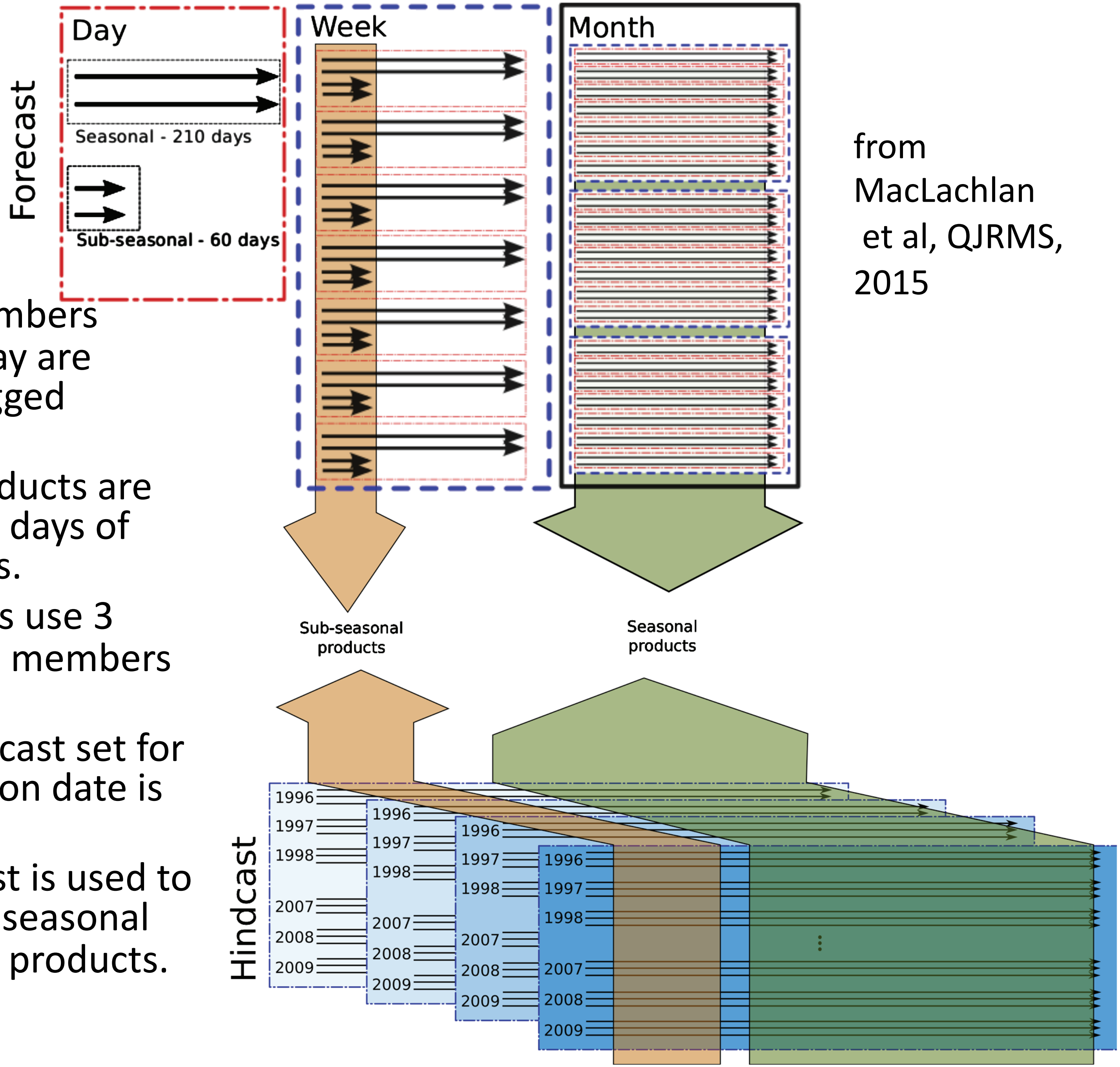


- "Fixed" – Hindcast data set run once for a particular model cycle
  - GOOD: Cheaper (if system not updated too frequently), larger ensemble sizes possible
  - BAD: Not always matching dates



ALSO: "Burst" (large ensemble on set days) versus "lagged" (trickle of few forecasts each day) [see Bill's lecture]

The Met Office system



from MacLachlan et al, QJRMS, 2015

- Four forecast members initialized each day are combined in a lagged ensemble.
- Sub-seasonal products are generated from 7 days of forecast members.
- Seasonal products use 3 weeks of forecast members in the ensemble.
- Each week a hindcast set for a given initialization date is completed.
- The same hindcast is used to bias correct both seasonal and sub-seasonal products.

Seasonal forecasting within the C3S

- The C3S seasonal forecast products are based on data from several state-of-the-art seasonal prediction systems.
- Multi-system combinations, as well as predictions from the individual participating systems, are available.
- The centres currently providing forecasts to C3S are
  - ECMWF,
  - The Met Office
  - Météo-France
  - DWD
  - CMCC

SYSTEM		FORECASTS		HINDCASTS	
		ENSEMBLE SIZE and START DATES	PRODUCTION	ENSEMBLE SIZE and START DATES	PRODUCTION
ECMWF	System 4 (CDS system: 4)	51 members start on the 1st	real-time	15 members start on the 1st	fixed dataset
	SEAS5 (CDS system: 5)	51 members start on the 1st	real-time	25 members start on the 1st	fixed dataset
Météo-France	System 5 (CDS system: 5)	51 members [(a)] 26 start on the first Wednesday after the 19th 25 start on the first Wednesday after the 12th	real-time	15 members start on the first Wednesday after the 19th [(a)]	fixed dataset
	System 6 (CDS system: 6)	51 members 1 starts on the 1st 25 start on the 25th 25 start on the 20th	real-time	25 members 1 starts on the 1st 12 start on the 25th 12 start on the 20th	fixed dataset
Met Office	GloSea5 [(b)] (CDS system: 12,13, 14 [(d)])	2 members start each day [(c)]	real-time	7 members on the 1st 7 members on the 9th 7 members on the 17th 7 members on the 25th	on-the-fly produced around 4-6 weeks in advance
CMCC	SPSv3 (CDS system: 3)	50 members start on the 1st	real-time	40 members start on the 1st	fixed dataset
DWD	GCFS2.0 (CDS system: 2)	50 members start on the 1st	real-time	30 members start on the 1st	

Bewildering array of data access choices

FTP server (NCEP)

Web Portal data order (NOAA)

Thredds servers (ISIMIP)

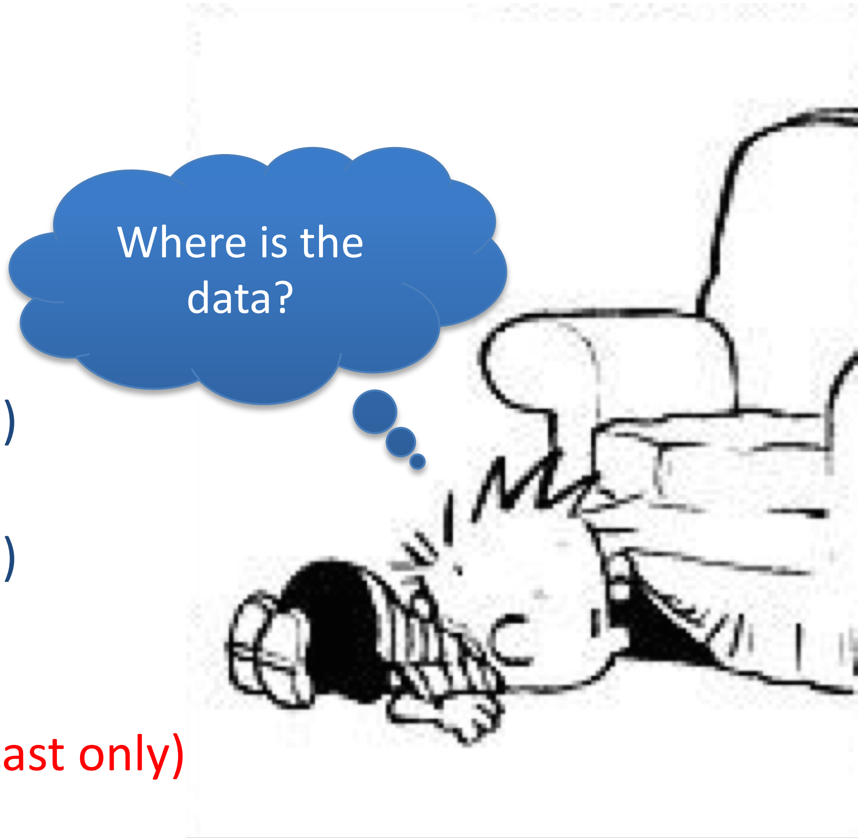
Web Portal graphical interface (Climate explorer)

Python API data interface (ECMWF, C3S)

remote processing toolboxes (IRIDL, C3S)

Common go-to locations, many of which will be introduced this week

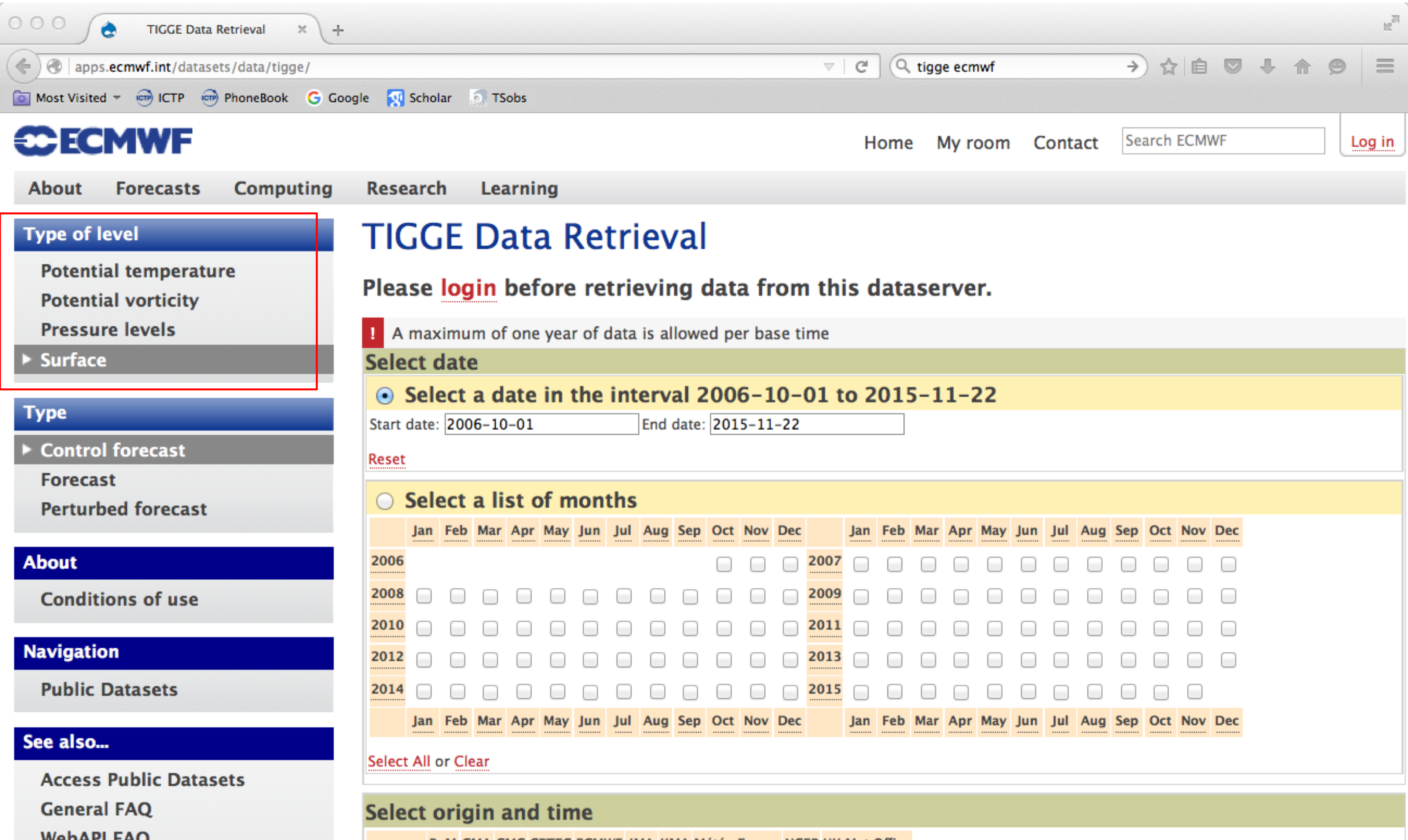
- Now: observations
  - IRI data library
  - Data originator portal
- Reanalysis (ERAI/ERA5)
  - ECMWF
  - Copernicus C3S
- Short range (TIGGE)
  - ECMWF (research only, not real time)
- Subseasonal S2S
  - ECMWF (research only, not real time)
- Seasonal
  - NMME (USA systems, monthly)
  - CHFP (global centres, monthly, hindcast only)
  - ECWMF (EUROSIP)
  - Copernicus C3S
- Decadal to Climate change (CMIP)
  - CMIP on the earth system grid (ESG)
  - KNMI climate explorer
  - Copernicus C3S



TIGGE: **the THORPEX Interactive Grand Global Ensemble**

- TIGGE is a key component of THORPEX **(the Observing System Research and Predictability Experiment)**: a World Weather Research Programme (WWRP) programme to accelerate the improvements in the accuracy of 1-day to 2 week high-impact weather forecasts.
- The TIGGE archive consists of ensemble forecast data from ten global NWP centres, starting from October 2006
- Available for scientific research (not real-time)
- THORPEX programme finishes at the end of 2014, TIGGE will continue for a further 5 years, when its future will be reviewed.

Data portal: http://apps.ecmwf.int/datasets/data/tigge/



TIGGE Data Retrieval

apps.ecmwf.int/datasets/data/tigge/

tigge ecmwf

Most Visited ICTP PhoneBook Google Scholar TSobs

See also...

- Access Public Datasets
- General FAQ
- WebAPI FAQ
- Accessing forecasts
- GRIB decoder

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Select All or Clear

Select origin and time

	BoM	CMA	CMC	CPTEC	ECMWF	JMA	KMA	Météo France	NCEP	UK Met Office
00:00:00	☐	☐	☐	☐	☐	☐	☐		☐	☐
06:00:00		☐						☐	☐	☐
12:00:00	☐	☐	☐	☐	☐	☐	☐		☐	☐
18:00:00								☐	☐	☐

Select All or Clear

Select step

☐ 0 ☐ 6 ☐ 12 ☐ 18 ☐ 24 ☐ 30 ☐ 36 ☐ 42 ☐ 48 ☐ 54 ☐ 60 ☐ 66 ☐ 72 ☐ 78 ☐ 84
☐ 90 ☐ 96 ☐ 102 ☐ 108 ☐ 114 ☐ 120 ☐ 126 ☐ 132 ☐ 138 ☐ 144 ☐ 150 ☐ 156 ☐ 162 ☐ 168 ☐ 174
☐ 180 ☐ 186 ☐ 192 ☐ 198 ☐ 204 ☐ 210 ☐ 216 ☐ 222 ☐ 228 ☐ 234 ☐ 240 ☐ 246 ☐ 252 ☐ 258 ☐ 264
☐ 270 ☐ 276 ☐ 282 ☐ 288 ☐ 294 ☐ 300 ☐ 306 ☐ 312 ☐ 318 ☐ 324 ☐ 330 ☐ 336 ☐ 342 ☐ 348 ☐ 354
☐ 360 ☐ 366 ☐ 372 ☐ 378 ☐ 384

Select All or Clear

Select parameter

☐ 2 metre dewpoint temperature	☐ 2 metre temperature
☐ 10 metre U wind component	☐ 10 metre V wind component
☐ Convective available potential energy	☐ Convective inhibition
☐ Field capacity	☐ Land-sea mask
☐ Maximum temperature at 2 metres in the last 6 hours	☐ Mean sea level pressure

TIGGE Data Retrieval

apps.ecmwf.int/datasets/data/tigge/levtype=sfc/type=cf

tigge ecmwf

Most Visited ICTP PhoneBook Google Scholar TSobs

180	186	192	198	204	210	216	222	228	234	240	246	252	258	264
270	276	282	288	294	300	306	312	318	324	330	336	342	348	354
360	366	372	378	384										

Select All or Clear

Select parameter

2 metre dewpoint temperature	2 metre temperature
10 metre U wind component	10 metre V wind component
Convective available potential energy	Convective inhibition
Field capacity	Land-sea mask
Maximum temperature at 2 metres in the last 6 hours	Mean sea level pressure
Minimum temperature at 2 metres in the last 6 hours	Orography
Skin temperature	Snow Fall water equivalent
Snow depth water equivalent	Soil Moisture
Soil Temperature	Soil moisture top 20 cm
Soil temperature top 20 cm	Sunshine duration
Surface latent heat flux	Surface net solar radiation
Surface net thermal radiation	Surface pressure
Surface sensible heat flux	Top net thermal radiation
Total Cloud Cover	Total Precipitation
Total column water	Wilting point

Select All or Clear

Top of page

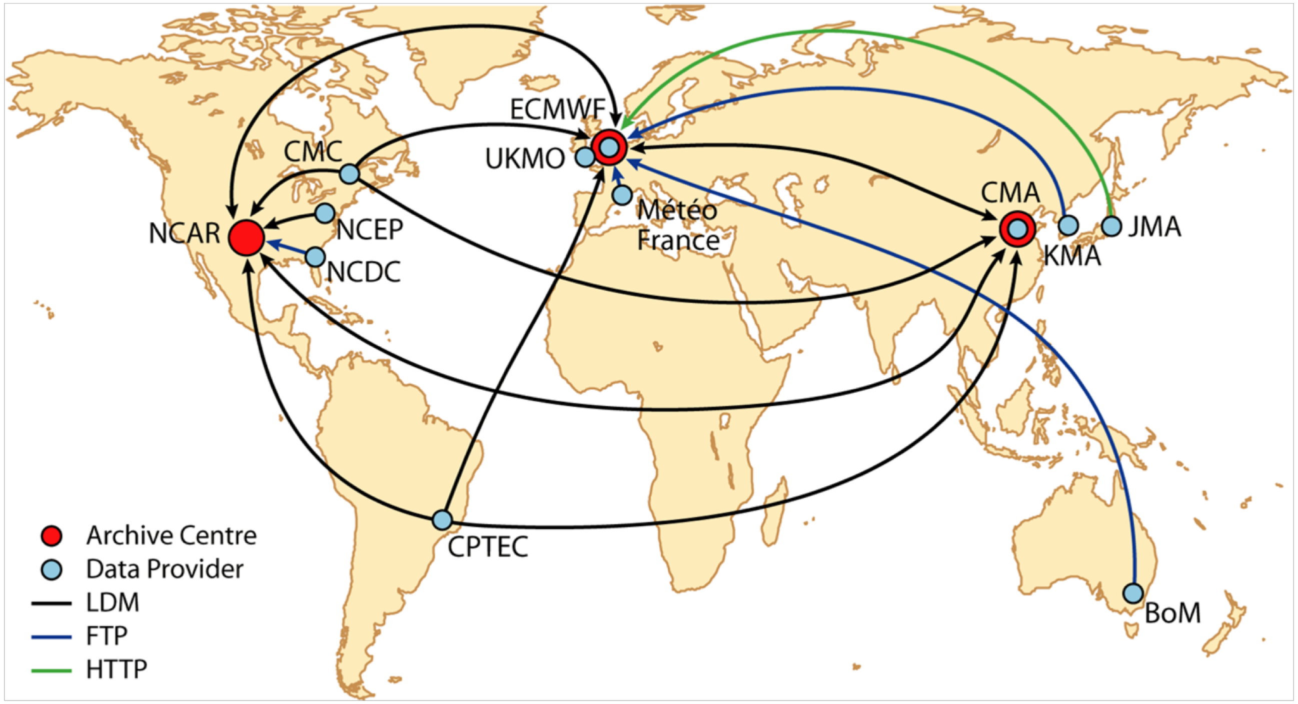
3. The TIGGE ensembles

The 9 TIGGE operational, medium-range, global ensembles use different methodologies to simulate initial-time and model uncertainties. Every day, the 7 ensembles that are still operational, put 436 forecasts into the TIGGE archive. These forecasts have horizontal resolution ranging from about 210 km to about 32 km, and forecast length between 10 and 16 days. They all simulate initial/observation and model uncertainties in different ways.

Centre	Initial unc. method (area)	Model unc.	Truncation (degrees, km)	# Vert Lev (TOA, hPa)	Fcst length (d)	# pert mem	#runs per day (UTC)	# mem per day	In TIGGE since
BMRC (AU)	SV(NH,SH)	NO	TL119 (1.5°; 210km)	19 (10.0)	10	32	2 (00/12)	66	Sep-07/Jul-10
CMA (CHI)	BV(globe)	NO	T213 (0.56°; 70km)	31 (10.0)	10	14	2 (00/12)	30	May-07
CPTEC (BR)	EOF(40S:30N)	NO	T126 (0.94°, 120km)	28 (0.1)	15	14	2 (00/12)	30	Feb-08
ECMWF (EU)	SV(NH, SH, TC) + EDA(globe)	YES	TL639 (0.28°; 32km) TL319 (0.56°; 65km)	91 (0.1)	0-10 15/32	50	2 (00/12)	102	Oct-06
JMA (JAP)	SV(NH, TR, SH)	YES	TL479 (0.38°; 50km)	60 (0.1)	11	25	2 (00/12)	52	Aug-11
KMA(KOR)	ETKF(globe)	YES	N320 (0.35°; 40km)	70 (0.1)	10	23	4 (00/06/12/18)	96	Dec-07
MSC (CAN)	EnKF(globe)	YES	600x300 (0.6°, 75km)	40 (2.0)	16/32	20	2 (00/12)	42	Oct-07
NCEP (USA)	ETR(globe)	YES	T254 (0.70°; 90km) T190 (0.95°; 120km)	28 (2.7)	0-8 8-16	20	4 (00/06/ 12/18)	84	Mar-07
UKMO (UK)	ETKF(globe)	YES	N216 (0.45°; 60km)	70 (0.1)	15	23	2 (00/12)	48	Oct-06/Jul-14

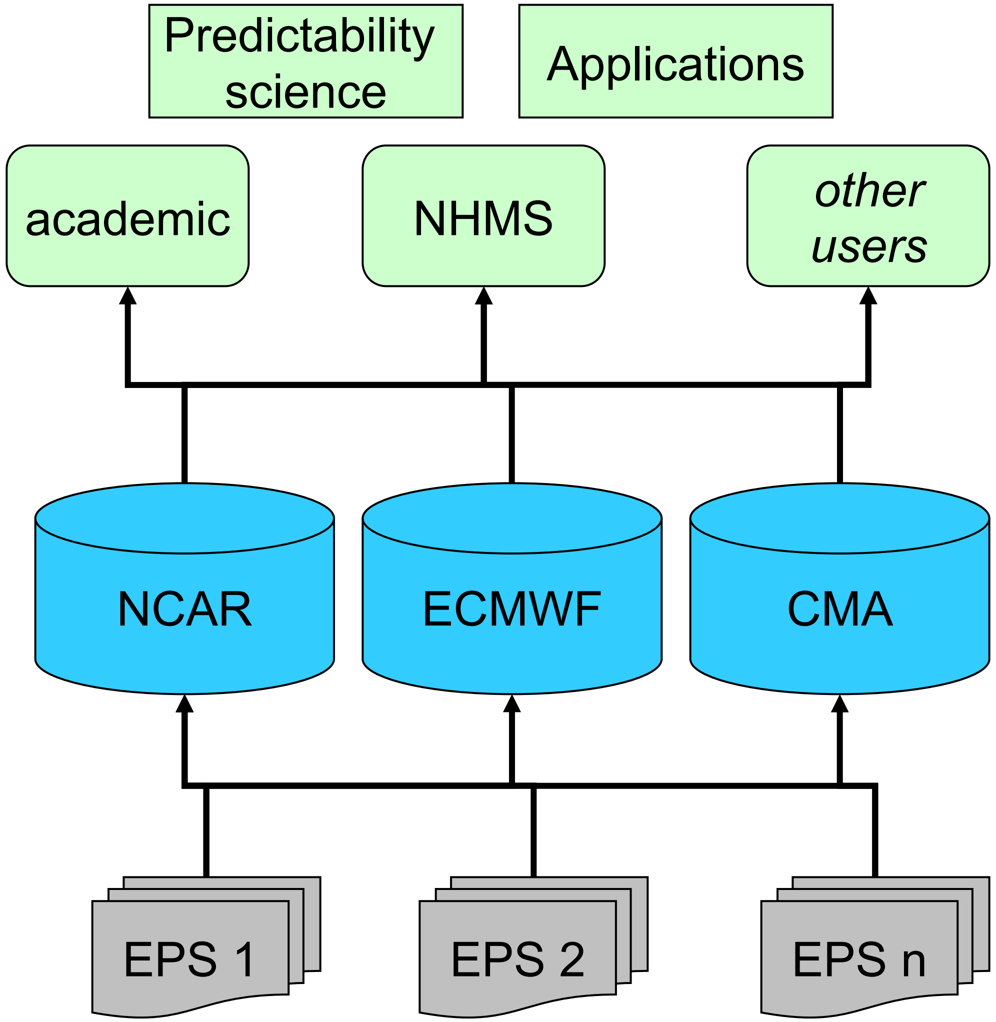
TIGGE data flows

- The ensemble prediction data is transferred from the data providers to one of the data centres (using LDM, FTP or HTTP).
- After checking, the data is then sent on to the other data centres.
- The data is archived and made available to users 48 hours after initial forecast time.



TIGGE features

- All data are archived at native resolution (on native grid when possible)
- Data may be interpolated on any limited-area lat-lon grid defined by the user just before download
- Field names, definitions, units, accumulation times, (etc.) are fully standardized
- Data gaps are continuously monitored and every effort is made to repair them quickly
- All data provided in GRIB2 (WMO standard data format)

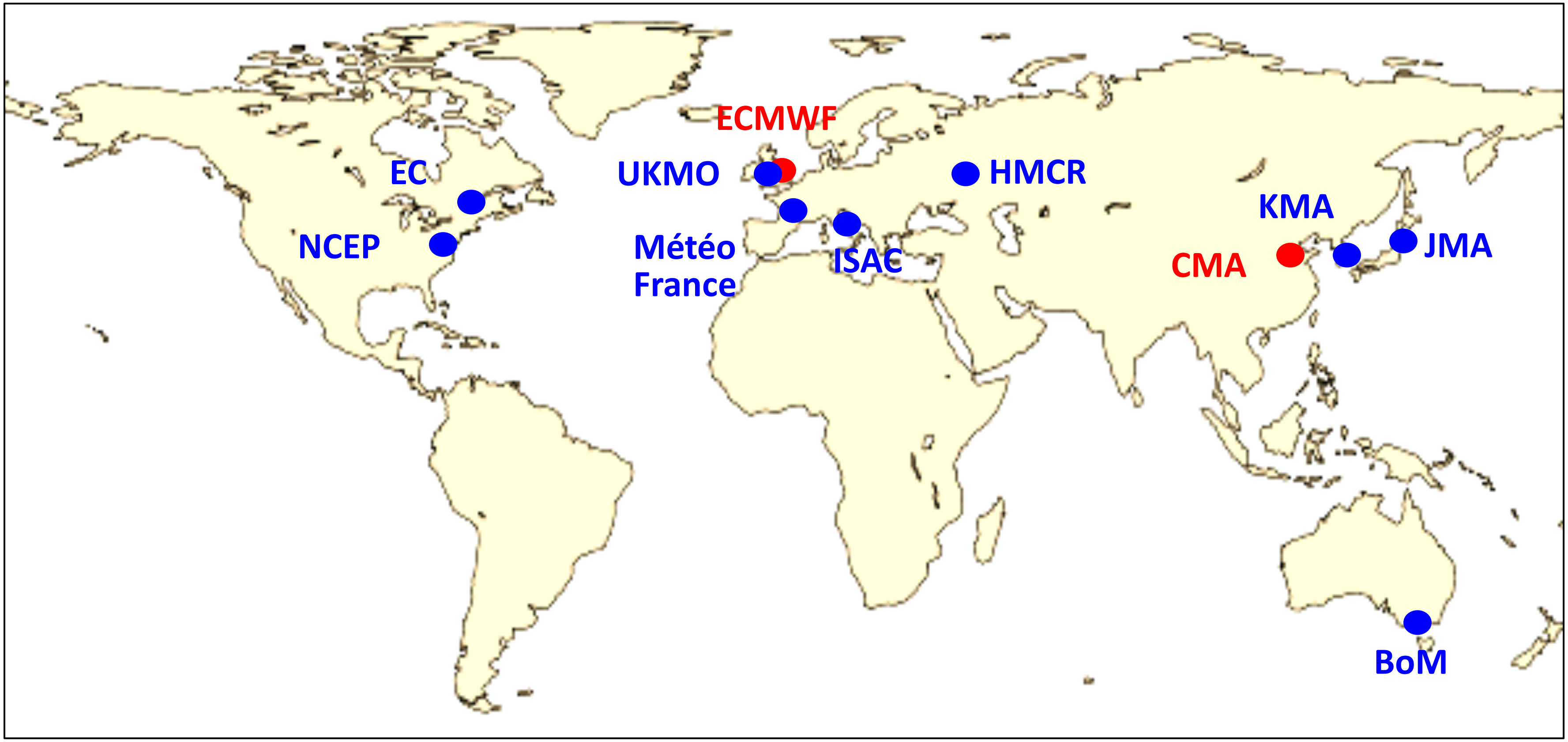


Subseasonal to Seasonal (S2S) Database

- Daily real-time forecasts + re-forecasts: 48 to 62 days lead time
- 3 weeks behind real-time
- Common grid (1.5x1.5 degree)
- Variables archived: about 80 variables including ocean variables, stratospheric levels and soil moisture and temperature
- Archived in GRIB2 – NETCDF conversion planned
- Database opened in May 2015, now 9 models available

Contributing centres to S2S

● Data provider (11) ● Archiving centre (2)



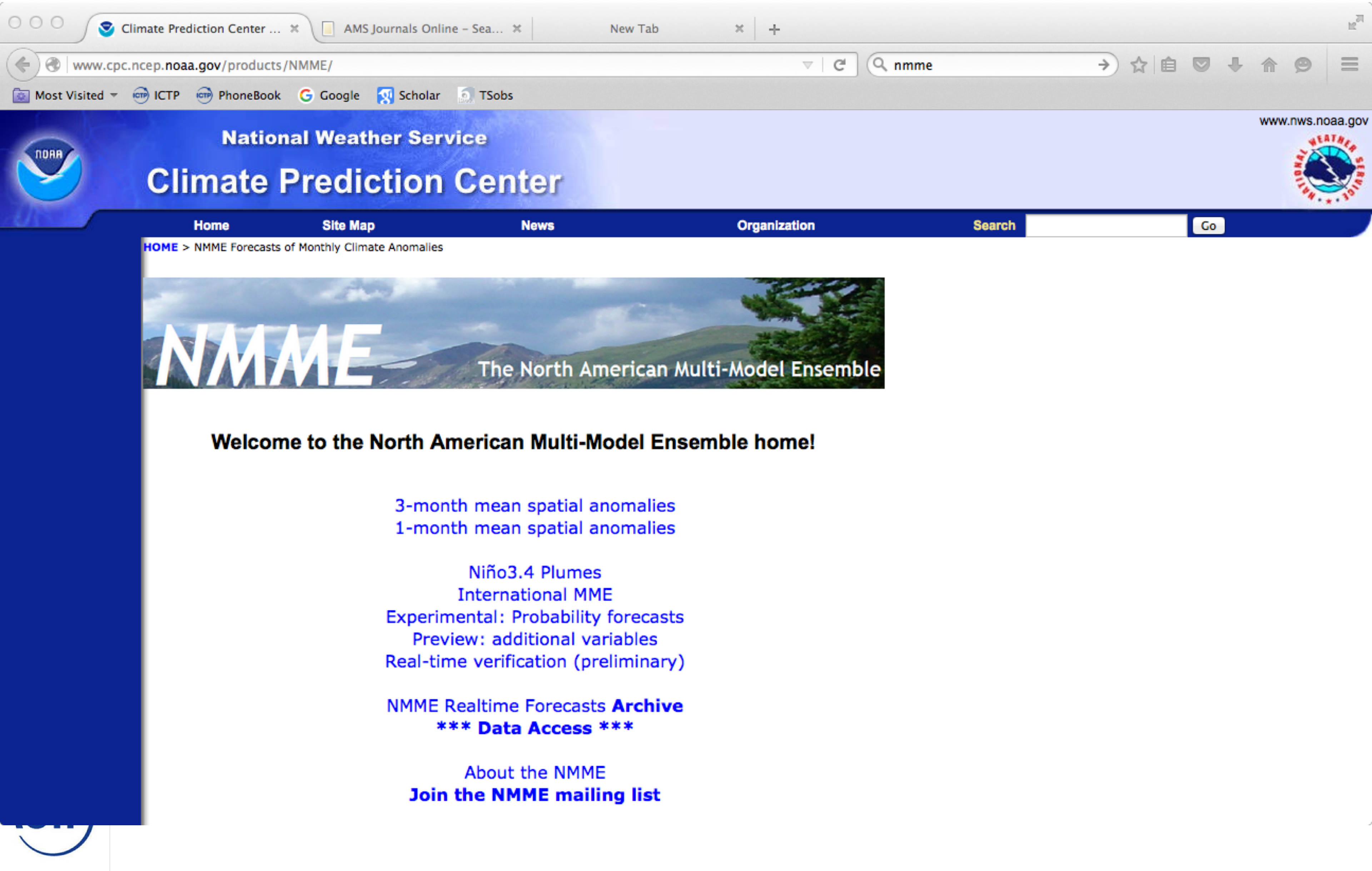
S2S partners

	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-46	T639/319L91	51	2/week	On the fly	Past 20y	2/weekly	11
UKMO	D 0-60	N216L85	4	daily	On the fly	1989-2003	4/month	3
NCEP	D 0-44	N126L64	4	4/daily	Fix	1999-2010	4/daily	1
EC	D 0-35	0.6x0.6L40	21	weekly	On the fly	Past 15y	weekly	4
BoM	D 0-60	T47L17	33	weekly	Fix	1981-2013	6/month	33
JMA	D 0-34	T159L60	50	weekly	Fix	1979-2009	3/month	5
KMA	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
CMA	D 0-45	T106L40	4	daily	Fix	1992-now	daily	4
Met.Fr	D 0-60	T127L31	51	monthly	Fix	1981-2005	monthly	11
CNR	D 0-32	0.75x0.56 L54	40	weekly	Fix	1981-2010	6/month	1
HMCR	D 0-63	1.1x1.4 L28	20	weekly	Fix	1981-2010	weekly	10

ICTP

See ICTP S2S school: http://indico.ictp.it/event/a14264/

NMME


Climate Prediction Center ...
AMS Journals Online – Sea...
New Tab
www.cpc.ncep.noaa.gov/products/NMME/
nmme
Most Visited
ICTP
PhoneBook
Google
Scholar
TSobs
www.nws.noaa.gov
National Weather Service
Climate Prediction Center
Home
Site Map
News
Organization
Search
Go
HOME > NMME Forecasts of Monthly Climate Anomalies
NMME
The North American Multi-Model Ensemble
Welcome to the North American Multi-Model Ensemble home!
3-month mean spatial anomalies
1-month mean spatial anomalies
Niño3.4 Plumes
International MME
Experimental: Probability forecasts
Preview: additional variables
Real-time verification (preliminary)
NMME Realtime Forecasts Archive
*** Data Access ***
About the NMME
Join the NMME mailing list

NMME

- Read the user guide!
- Refer to Kirtman et al. 2014 BAMS article
- Who is involved?
  - NOAA NCEP CFSv1 (retired October, 2012)
  - NOAA NCEP CFSv2
  - IRI ECHAMA and ECHAMF (retired August, 2012)
  - NASA Goddard Space Flight Center (GSFC) GEOS5
  - NCAR/University of Miami CCSM3.0
  - GFDL CM2.1
  - GFDL CM2.5 [FLORa06 and FLORb01] (joined March, 2014)
  - Environment Canada CanCM3 and CanCM4 (joined September, 2012)
- Each real-time forecast available by the 9^{th} of the month

What's available for real-time?

- **Spatial anomaly forecasts**
  - one-month: ensemble mean monthly anomaly forecasts for each model based on their climatology from the hindcasts. The models are equally weighted, meaning the ensemble means for each model are calculated first, then averaged together to form the multi-model mean. Forecasts for the following seven months are available. (also 3 month averages)
- Skill maps are based on the monthly/three-month anomaly correlation for each variable's ensemble mean from the 1982-2010 hindcasts. Skill maps are available for the individual models and for the NMME.
- Nino Plumes
- International MME: EUROSIP (maps only, no digital data)
- Experimental probability forecasts: probability forecasts are a different representation of the model data, and are prepared in parallel to the the anomaly forecasts.
- **Preview of additional variables**: Five variables are available in "preview" mode: 200 mb height, maximum and minimum 2 m surface temperature, runoff, and soil moisture.
- Preliminary real-time verification: Skill assessments of the real-time forecasts are updated monthly between the 6th - 8th.

Hindcasts (phase 1)

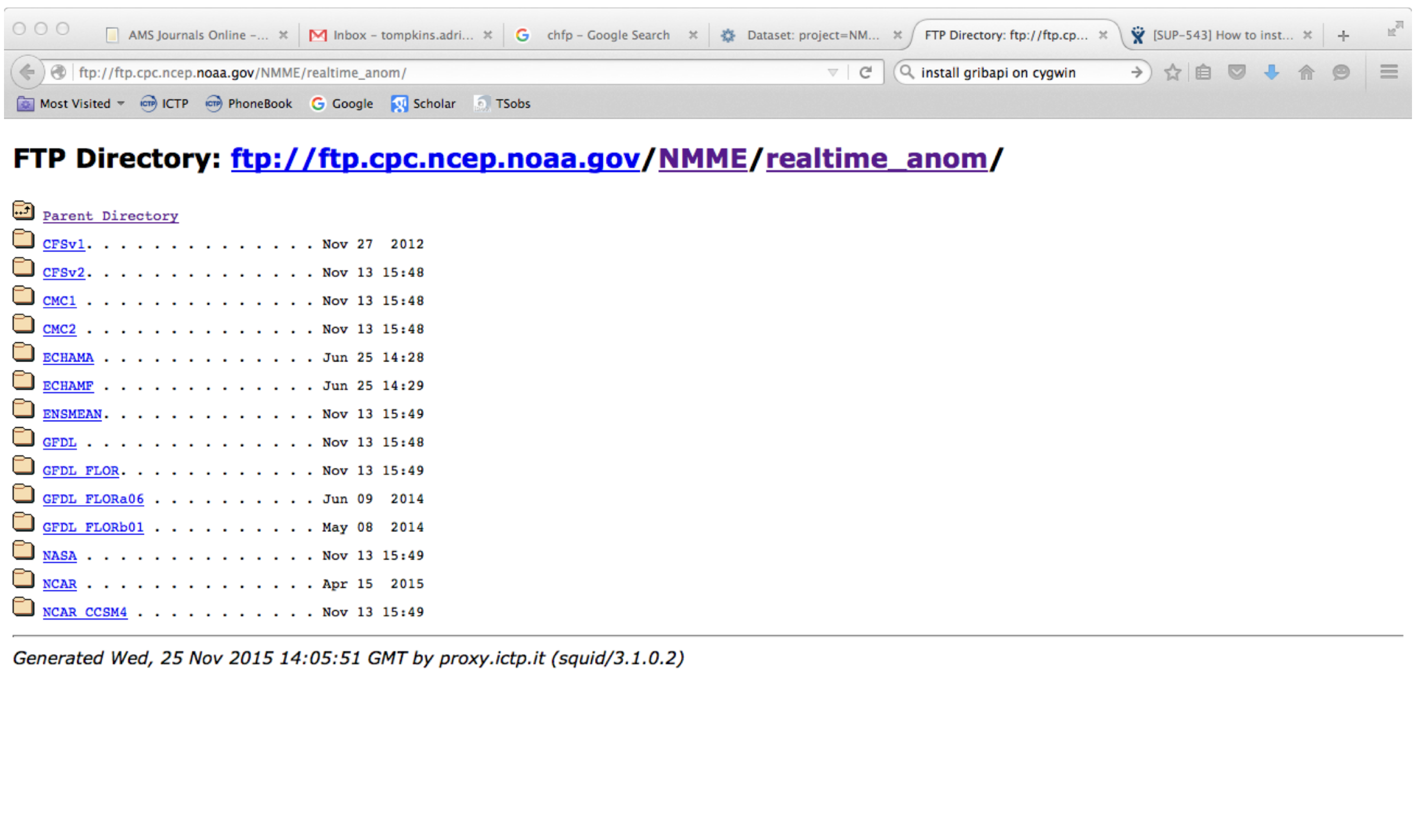
- Each model has a complete set of retrospective forecasts for 1982-2010 (CFSv1=1982-2009)
- These hindcasts are used for model calibration and for studies.
- Only monthly means are available, for the three variables: sea-surface temperature, 2 meter temperature, and precipitation rate, at a global, 1-degree latitude by 1-degree longitude resolution.
- The phase 1 hindcasts are available on the IRI datalibrary: http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/

Hindcasts phase 2

- Many more variables are available on the earth system grid: https://www.earthsystemgrid.org/search.html?Project=NMME
- Hindcast period covers 1980-2015 but the core period is 1982-2012
- Files can be:
  - downloaded through a Web Browser,
  - downloaded in bulk via a WGET script,
  - requested from the Deep Storage Archives (SRM).
- list of variables available here: http://www.cpc.ncep.noaa.gov/products/ctb/nmme/NMME_Data_Strategy.pdf

Real time forecasts:

- These are available on an ftp archive: ftp://ftp.cpc.ncep.noaa.gov/NMME/realtime_anom/
- Access through the web interface or ftp
- To retrieve absolute fields, then you need the climatologies: ftp://ftp.cpc.ncep.noaa.gov/NMME/clim/



FTP Directory: ftp://ftp.cpc.ncep.noaa.gov/NMME/realtime_anom/

```
Parent Directory
CFSv1. . . . . . . . . . . . . . Nov 27  2012
CFSv2. . . . . . . . . . . . . . Nov 13 15:48
CMC1 . . . . . . . . . . . . . . Nov 13 15:48
CMC2 . . . . . . . . . . . . . . Nov 13 15:48
ECHAMA . . . . . . . . . . . . . Jun 25 14:28
ECHAMF . . . . . . . . . . . . . Jun 25 14:29
ENSMEAN. . . . . . . . . . . . . Nov 13 15:49
GFDL . . . . . . . . . . . . . . Nov 13 15:48
GFDL_FLOR. . . . . . . . . . . . Nov 13 15:49
GFDL_FLORa06 . . . . . . . . . . Jun 09  2014
GFDL_FLORb01 . . . . . . . . . . May 08  2014
NASA . . . . . . . . . . . . . . Nov 13 15:49
NCAR . . . . . . . . . . . . . . Apr 15  2015
NCAR_CCSM4 . . . . . . . . . . . Nov 13 15:49
```

Generated Wed, 25 Nov 2015 14:05:51 GMT by proxy.ictp.it (squid/3.1.0.2)

Data locations for realtime

MODEL

VARIABLE (rain, temperature, SST)

ENSEMBLE MEMBER

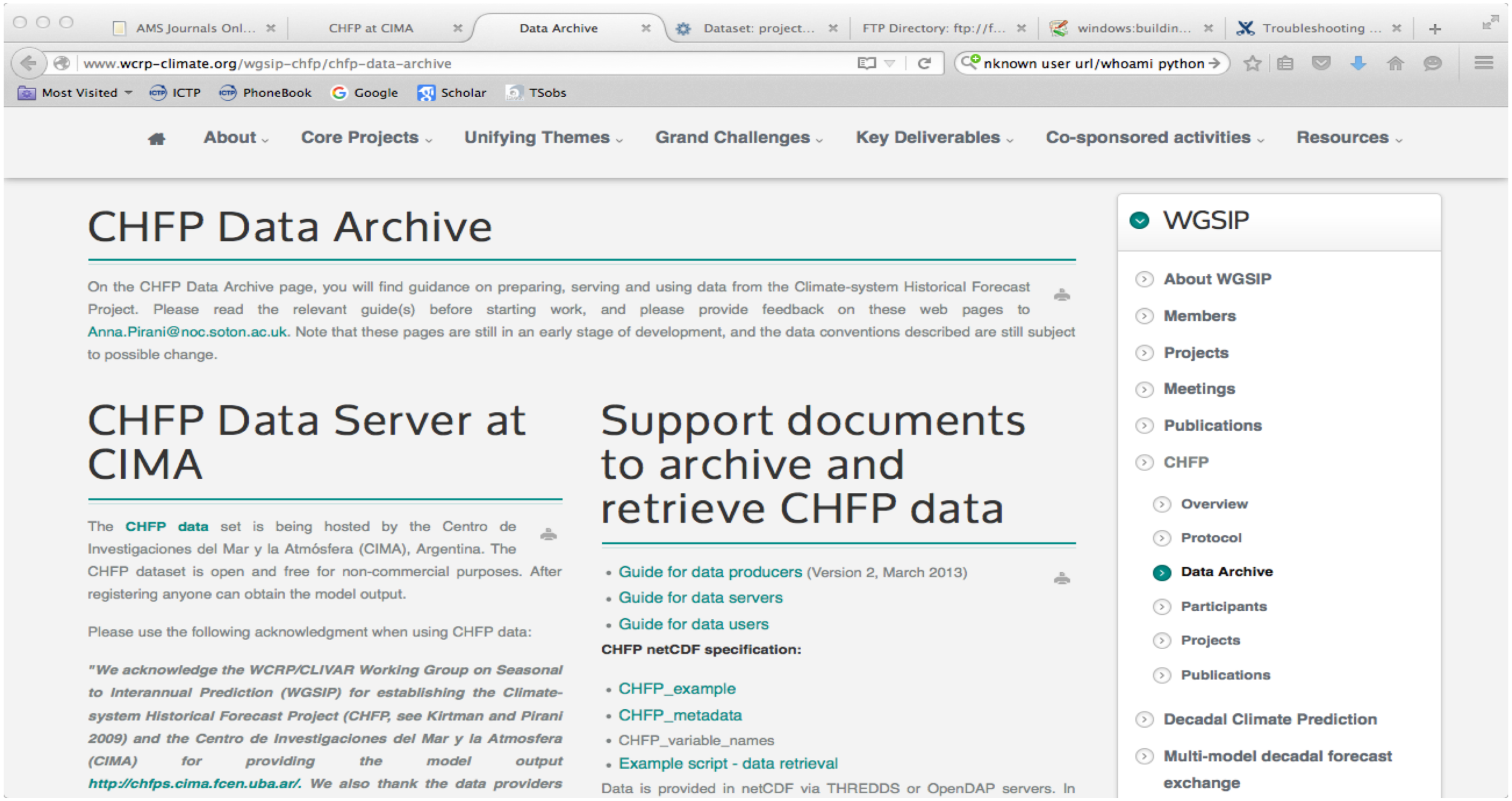
OBVIOUS!

CFSv2/2011110800/prate.2011110306.01.CFSv2.anom.avrg.1x1.grb

FORECAST ISSUE DATE

FORECAST START DATE

CHFP: Climate-system Historical Forecast Project

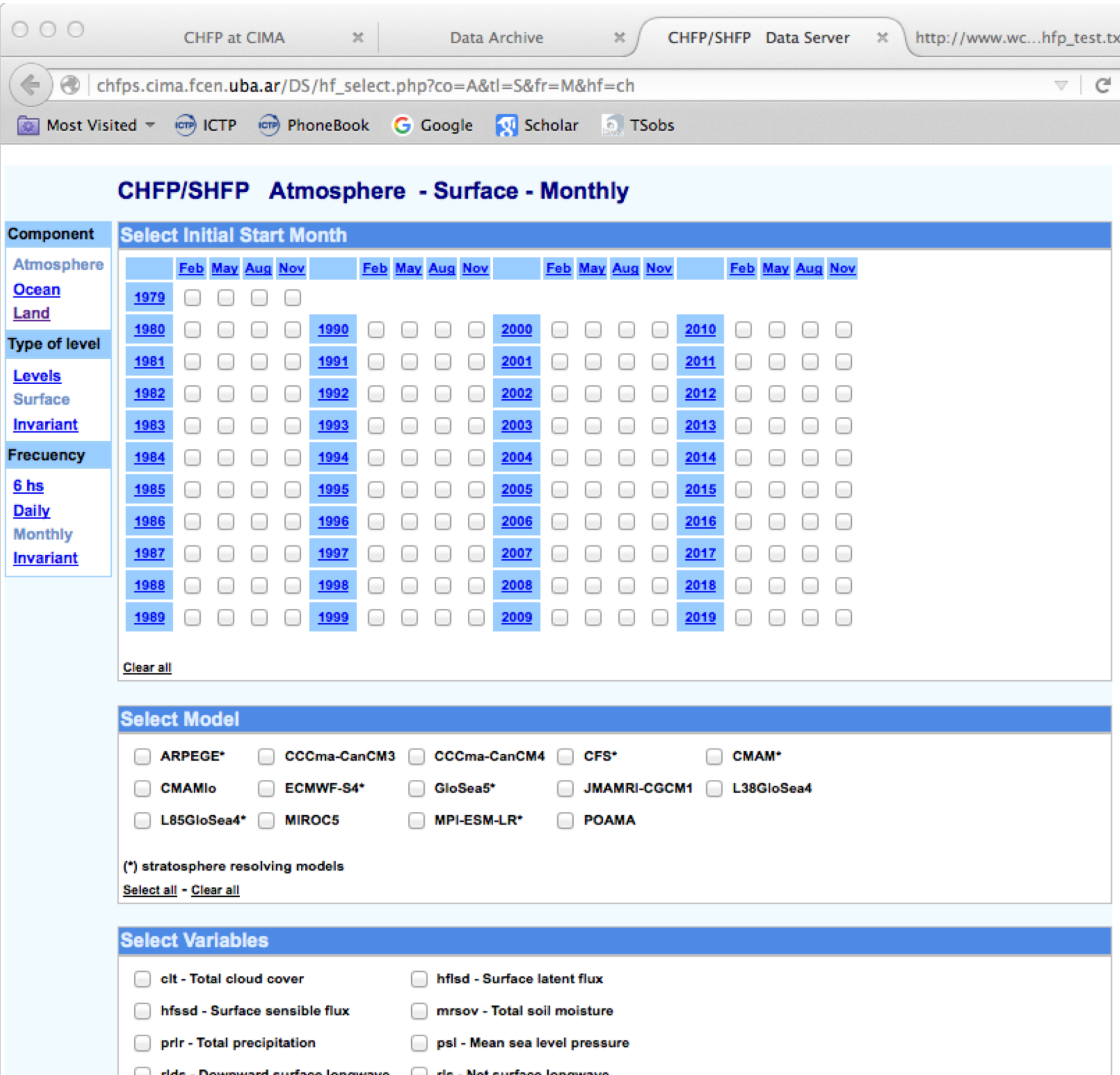


ICTP

CHFP

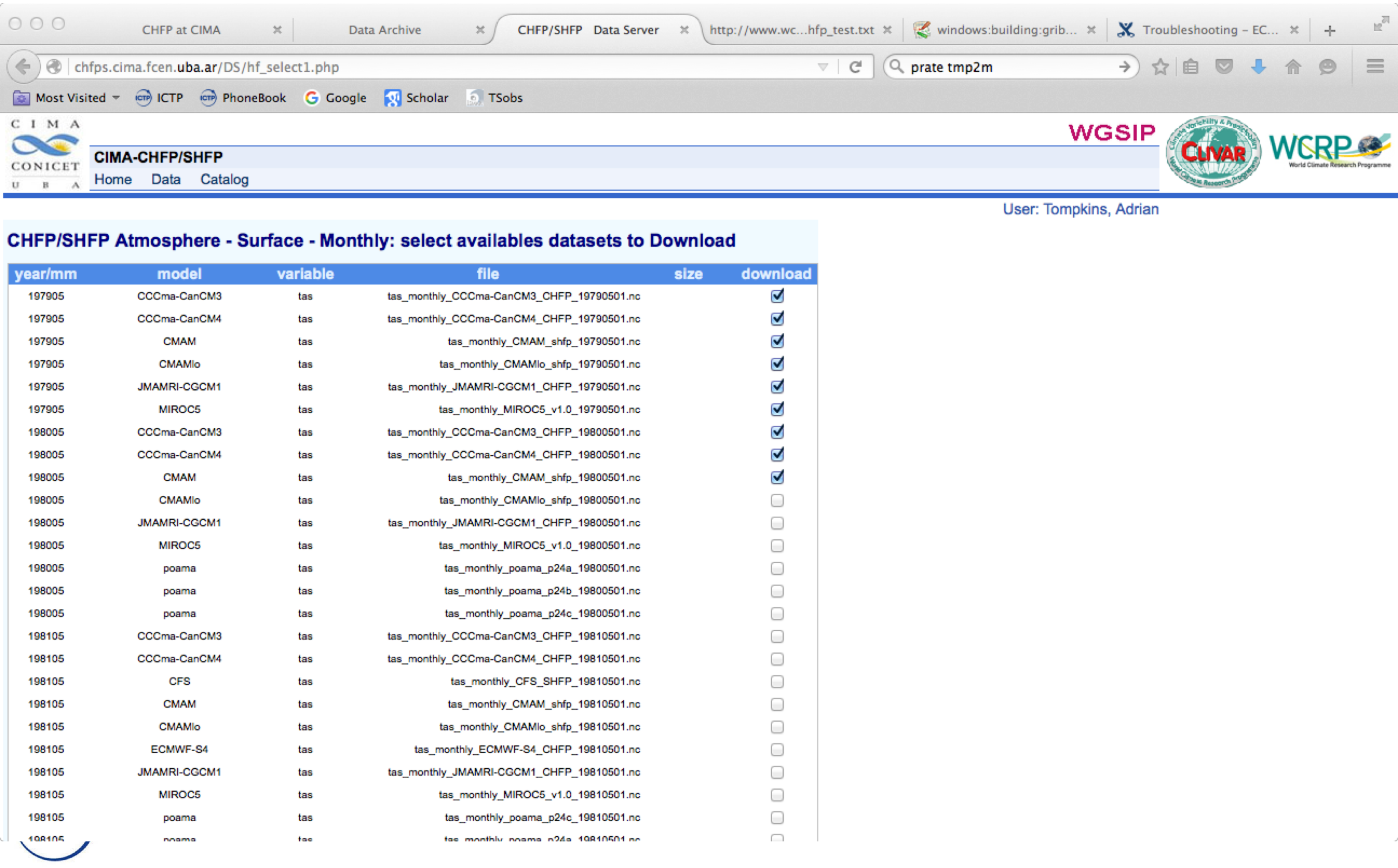
- A WGSIP (working group on [sub]seasonal to internannual[decadal] prediction) project
- Idea is to create a long-term archive for seasonal prediction model's hindcast (reforecast) datasets.
- No operational data archived, used as a research tool
- Idea is for a "living" archive, that is updated as newer model versions come online to document long-term improvements in seasonal prediction
- http://www.wcrp-climate.org/wgsip-chfp/chfp-data-archive
- http://chfps.cima.fcen.uba.ar/

What is in there?



- 4 start dates a year
- Mostly monthly mean variables
- limited daily data

Web data interface



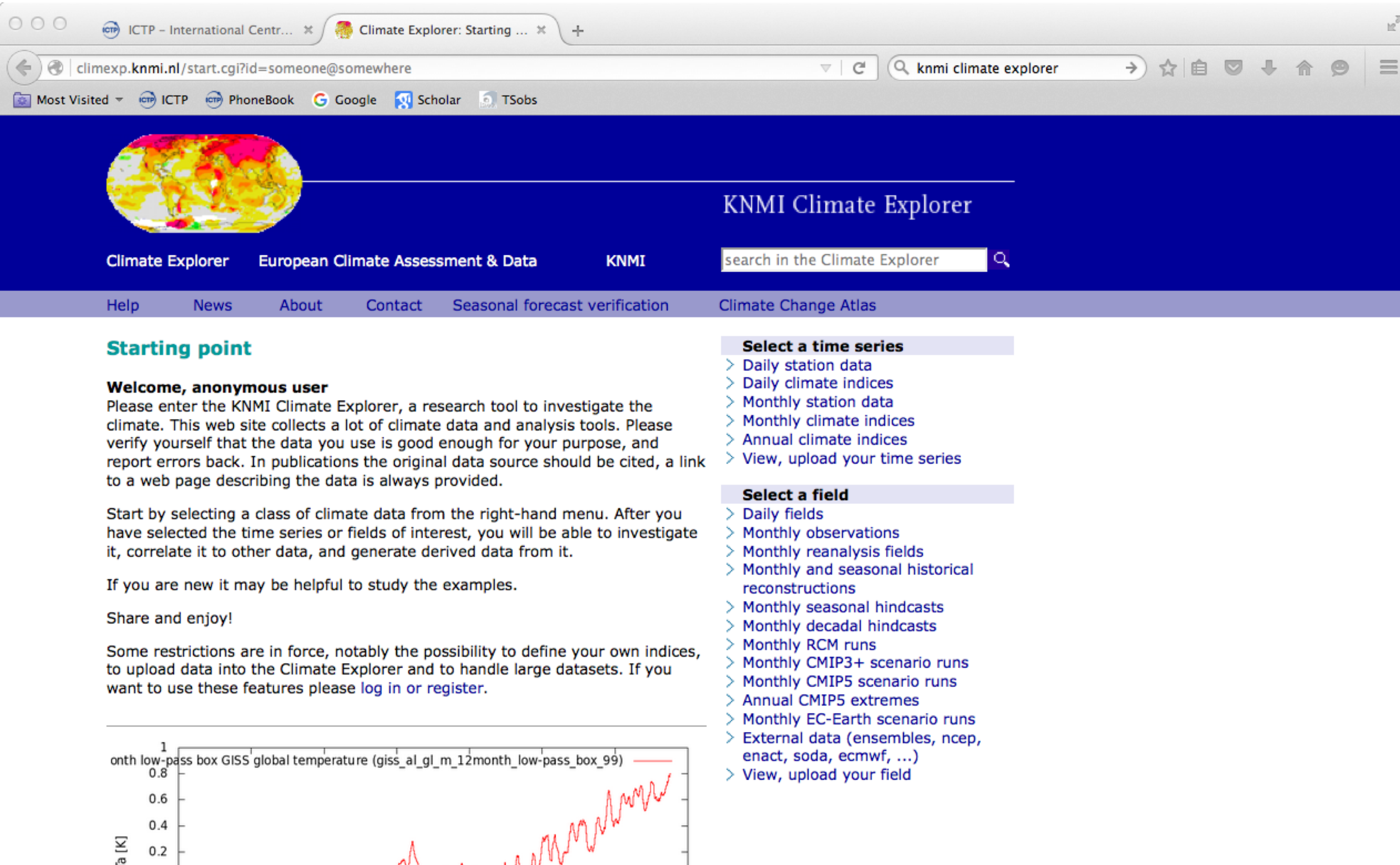
CHFP/SHFP Atmosphere - Surface - Monthly: select availables datasets to Download

year/mm	model	variable	file	size	download
197905	CCCma-CanCM3	tas	tas_monthly_CCCma-CanCM3_CHFP_19790501.nc		☑
197905	CCCma-CanCM4	tas	tas_monthly_CCCma-CanCM4_CHFP_19790501.nc		☑
197905	CMAM	tas	tas_monthly_CMAM_shfp_19790501.nc		☑
197905	CMAMlo	tas	tas_monthly_CMAMlo_shfp_19790501.nc		☑
197905	JMAMRI-CGCM1	tas	tas_monthly_JMAMRI-CGCM1_CHFP_19790501.nc		☑
197905	MIROC5	tas	tas_monthly_MIROC5_v1.0_19790501.nc		☑
198005	CCCma-CanCM3	tas	tas_monthly_CCCma-CanCM3_CHFP_19800501.nc		☑
198005	CCCma-CanCM4	tas	tas_monthly_CCCma-CanCM4_CHFP_19800501.nc		☑
198005	CMAM	tas	tas_monthly_CMAM_shfp_19800501.nc		☑
198005	CMAMlo	tas	tas_monthly_CMAMlo_shfp_19800501.nc		☐
198005	JMAMRI-CGCM1	tas	tas_monthly_JMAMRI-CGCM1_CHFP_19800501.nc		☐
198005	MIROC5	tas	tas_monthly_MIROC5_v1.0_19800501.nc		☐
198005	poama	tas	tas_monthly_poama_p24a_19800501.nc		☐
198005	poama	tas	tas_monthly_poama_p24b_19800501.nc		☐
198005	poama	tas	tas_monthly_poama_p24c_19800501.nc		☐
198105	CCCma-CanCM3	tas	tas_monthly_CCCma-CanCM3_CHFP_19810501.nc		☐
198105	CCCma-CanCM4	tas	tas_monthly_CCCma-CanCM4_CHFP_19810501.nc		☐
198105	CFS	tas	tas_monthly_CFS_SHFP_19810501.nc		☐
198105	CMAM	tas	tas_monthly_CMAM_shfp_19810501.nc		☐
198105	CMAMlo	tas	tas_monthly_CMAMlo_shfp_19810501.nc		☐
198105	ECMWF-S4	tas	tas_monthly_ECMWF-S4_CHFP_19810501.nc		☐
198105	JMAMRI-CGCM1	tas	tas_monthly_JMAMRI-CGCM1_CHFP_19810501.nc		☐
198105	MIROC5	tas	tas_monthly_MIROC5_v1.0_19810501.nc		☐
198105	poama	tas	tas_monthly_poama_p24c_19810501.nc		☐
198105	poama	tas	tas_monthly_poama_p24a_19810501.nc		☐

KNMI climate explorer

- Provides easy access to CMIP3 (daily&monthly) and CMIP5 (monthly) model output
- Some observational data also available
- Simple functionality allow online calculation of anomalies, trends and apply filters.
- Simple exercise sheet on the s2s clima-dods site

http://climexp.knmi.nl



Advanced School and Wor... | Climate Explorer: Select a ... | ICTP: Online Applications ... | ICTP: Online Applications ...

climexp.knmi.nl/selectfield_cmip5.cgi?id=someone@somewhere#ocean

knmi climate explorer

Most Visited | ICTP | PhoneBook | Google | Scholar | TSobs

model	exp	tas	tas min	tas max	pr	evsp sbl	pme	hurs	taz	psl
	piControl	1	1	1	1	1	1	1		1
bcc-csm1-1-m	historical	3	3	3	3	3	3	3	3	3
	rcp26	1	1	1	1	1	1	1	1	1
	rcp45	1	1	1	1	1	1	1	1	1
	rcp60	1	1	1	1	1	1	1	1	1
	piControl	1	1	1	1	1	1	1		1
BNU-ESM	historical	1	1	1	1	1	1	1	1	1
	rcp26	1	1	1	1	1	1	1	1	1
	rcp45	1	1	1	1	1	1	1	1	1
	rcp85	1	1	1	1	1	1	1	1	1
	piControl	1	1	1	1	1	1	1		1
CanESM2	historical	5	5	5	5	5	5	5	5	5
	rcp26	5	5	5	5	5	5	5	5	5
	rcp45	5	5	5	5	5	5	5	5	5
	rcp85	5	5	5		5			5	5

variable (tas=T2m,pr=precip)

model

Ensemble number

Emission Scenario

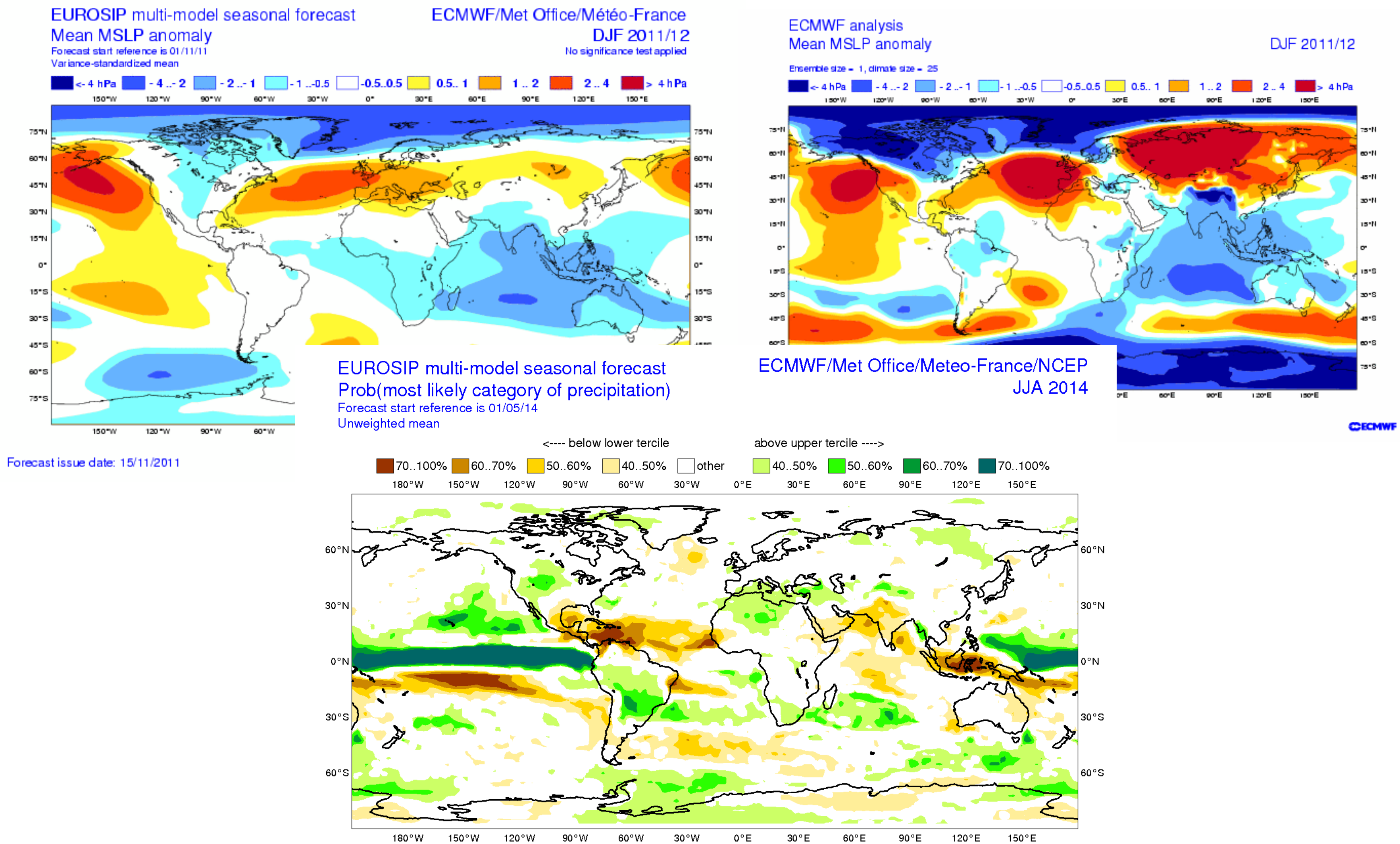
EUROSIP multi-model ensemble

- Four seasonal forecast models archived at ECMWF:
  - ECMWF – SYSTEM 4
  - Met Office – HADGEM model, Met Office ocean analyses
  - Météo-France – Météo-France model, Mercator ocean analyses
  - NCEP – CFSv2

- Unified system
  - Real-time since mid-2005
  - All data in ECMWF operational archive
  - Common operational schedule (products released at 12Z on 15th)
  - Recent changes at Met Office have limited the system somewhat

  - See "EUROSIP User Guide" on web for details, and also the ECMWF Newsletter article (Issue No. 118, Winter 2008/09)

EUROSIP web products

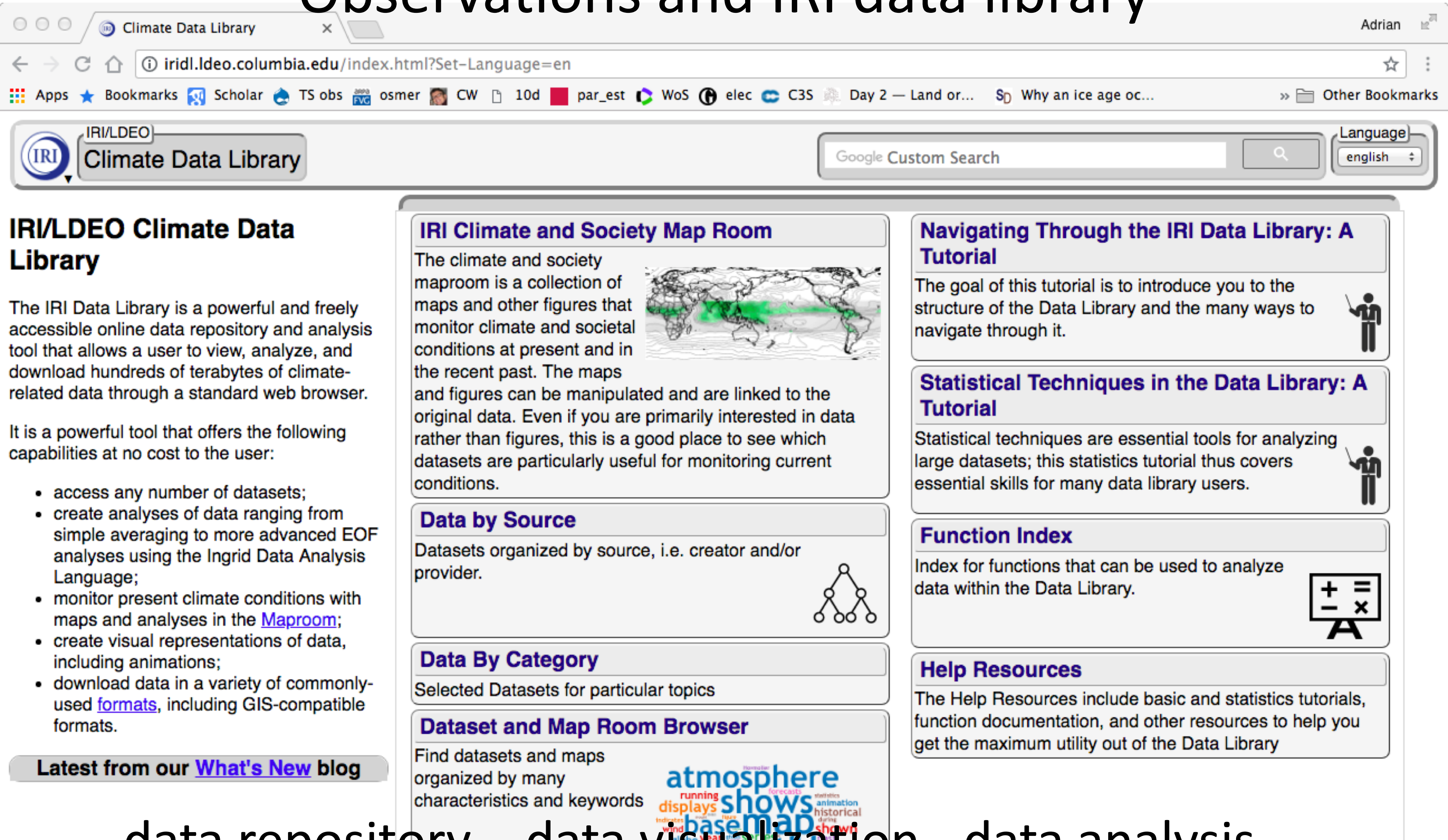


EUROSIP data

- Individual model data archived in MARS
  - NEW! Available in realtime, with ECMWFAPI and C3S API access...
  - C3S toolbox beta release for remote processing
- Multi-model data products
  - Created and archived in MARS
  - Available for dissemination, also for commercial customers

ICTP

Observations and IRI data library


Climate Data Library

iridl.ldeo.columbia.edu/index.html?Set-Language=en

Apps Bookmarks Scholar TS obs osmer CW 10d par_est WoS elec C3S Day 2 — Land or... Why an ice age oc... Other Bookmarks

IRI/LDEO Climate Data Library

Google Custom Search

Language english

IRI/LDEO Climate Data Library

The IRI Data Library is a powerful and freely accessible online data repository and analysis tool that allows a user to view, analyze, and download hundreds of terabytes of climate-related data through a standard web browser.

It is a powerful tool that offers the following capabilities at no cost to the user:

- access any number of datasets;
- create analyses of data ranging from simple averaging to more advanced EOF analyses using the Ingrid Data Analysis Language;
- monitor present climate conditions with maps and analyses in the Maproom;
- create visual representations of data, including animations;
- download data in a variety of commonly-used formats, including GIS-compatible formats.

Latest from our What's New blog

IRI Climate and Society Map Room

The climate and society maproom is a collection of maps and other figures that monitor climate and societal conditions at present and in the recent past. The maps and figures can be manipulated and are linked to the original data. Even if you are primarily interested in data rather than figures, this is a good place to see which datasets are particularly useful for monitoring current conditions.

Data by Source

Datasets organized by source, i.e. creator and/or provider.

Data By Category

Selected Datasets for particular topics

Dataset and Map Room Browser

Find datasets and maps organized by many characteristics and keywords

Navigating Through the IRI Data Library: A Tutorial

The goal of this tutorial is to introduce you to the structure of the Data Library and the many ways to navigate through it.

Statistical Techniques in the Data Library: A Tutorial

Statistical techniques are essential tools for analyzing large datasets; this statistics tutorial thus covers essential skills for many data library users.

Function Index

Index for functions that can be used to analyze data within the Data Library.

Help Resources

The Help Resources include basic and statistics tutorials, function documentation, and other resources to help you get the maximum utility out of the Data Library

data repository – data visualization - data analysis tool - Q: What are the advantages and disadvantages of such a platform?