



**The Abdus Salam
International Centre for Theoretical Physics**



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**Joint ICTP-IAEA Workshop on Vulnerability of Energy Systems to
Climate Change and Extreme Events**

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Projected changes in climate and weather extremes

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Outline

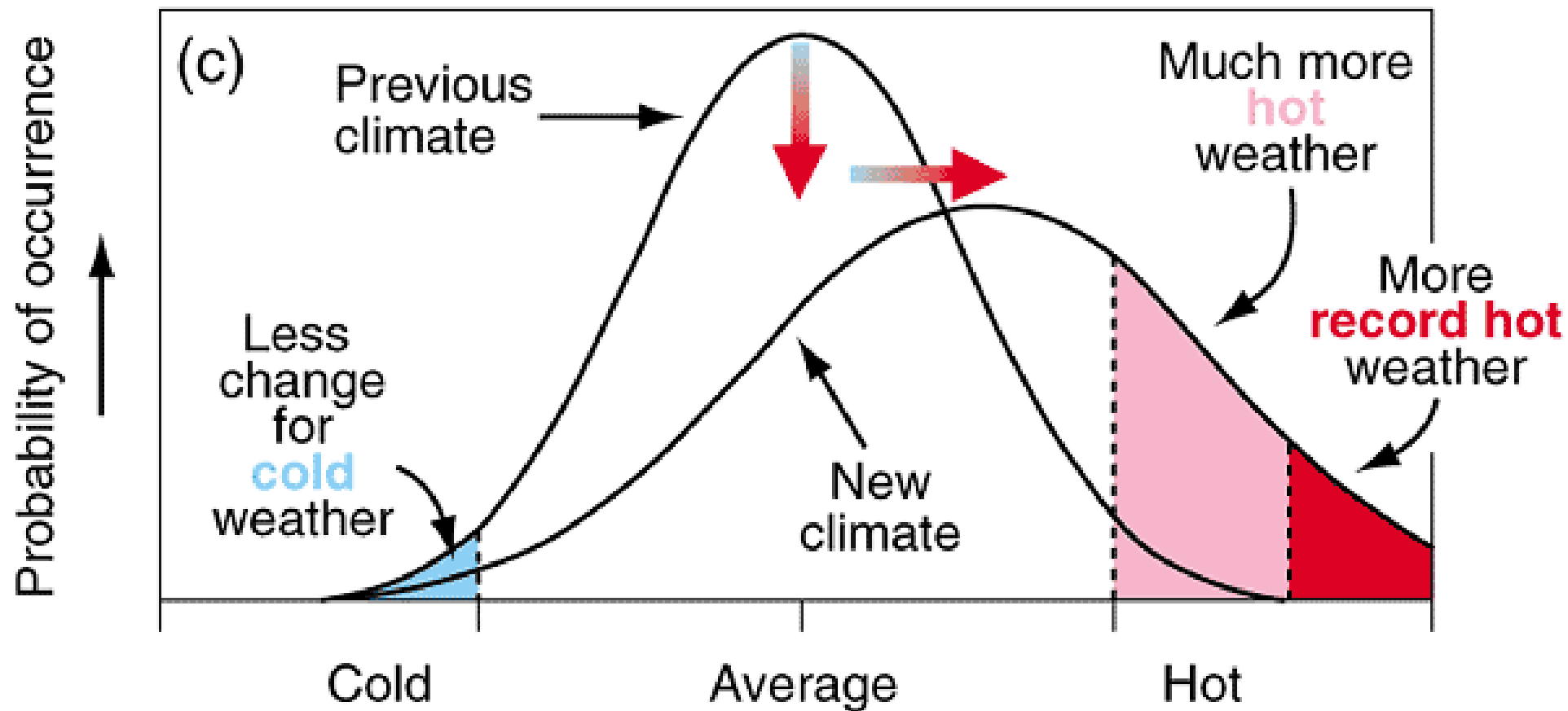
1. Caveats
2. CC and extremes
3. Extremes related to
 - Temperature
 - Precipitation
 - Storms
 - Other
4. Climate modelling and extremes
5. Uncertainties and Robust findings

Caveats

- Litterature study
- Metrics on extreme events vary a lot
- Studies based on varying assumptions
- Most recent studies are, of course, the most preliminary



Increase in mean and variance

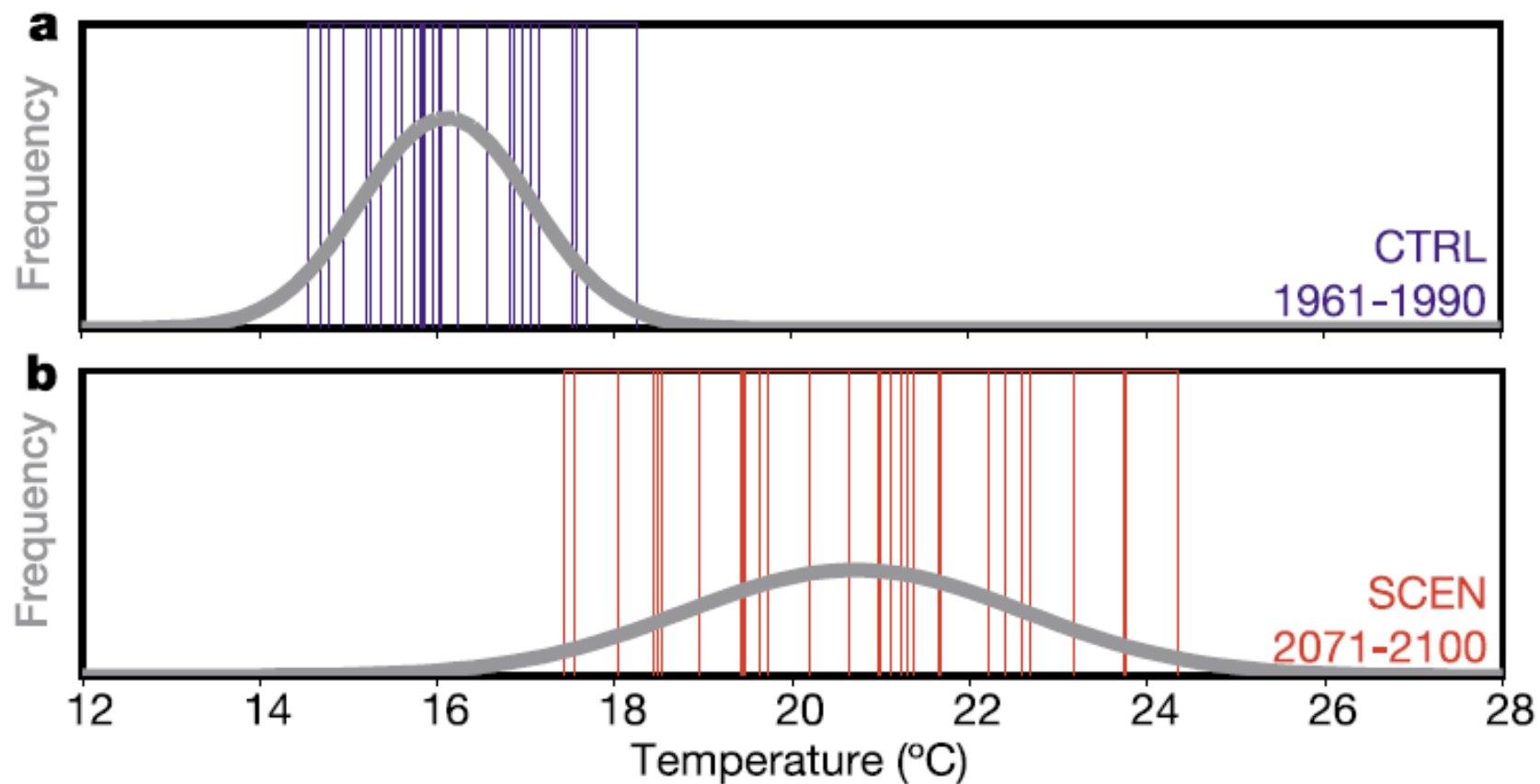


Expectations on CC and extremes

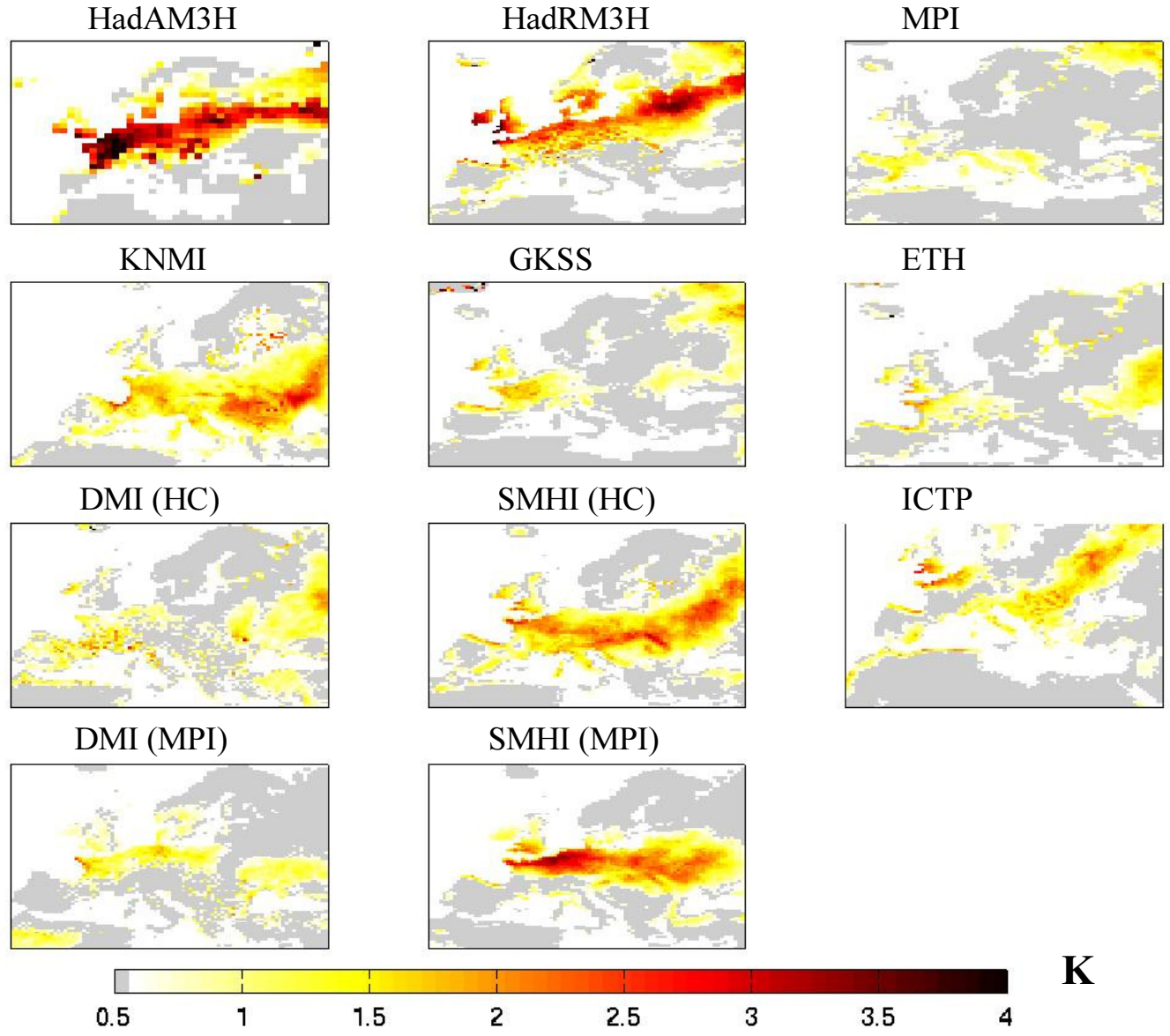
Warmer + fewer cold days & nights	Virtually certain (>99%)
Warmer + more frequent hot days & nights	Virtually certain
Warm spells + heat waves	Very likely (>90%) more
More heavy precipitation	Very likely
Droughts more widespread	Likely (>66%)
Intense tropical cyclone activity	Likely to increase
Incidence of extreme high SL	Likely to increase

Extremes related to Temperature

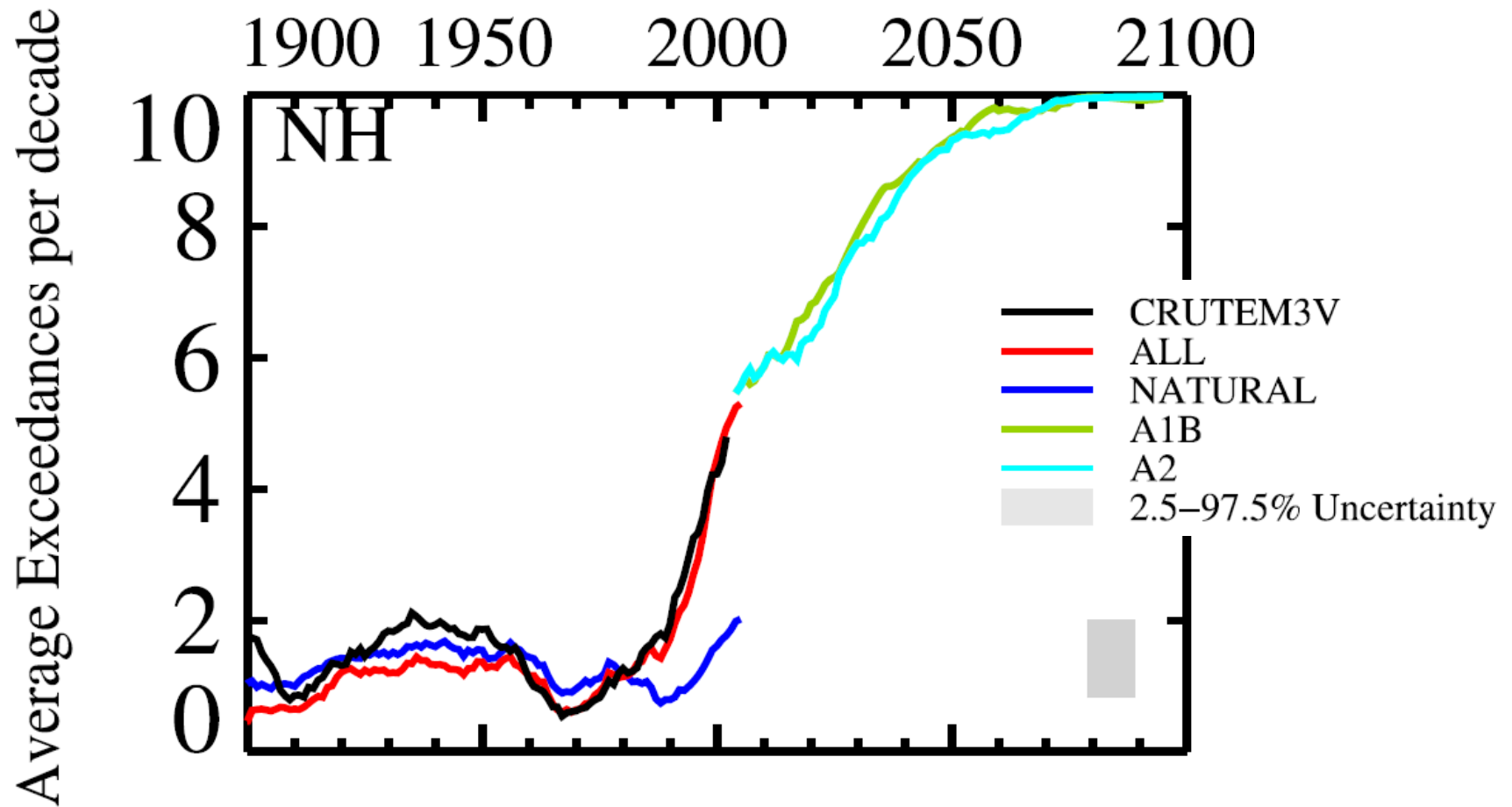
Recent and possible future summers (Switzerland) (RCM)



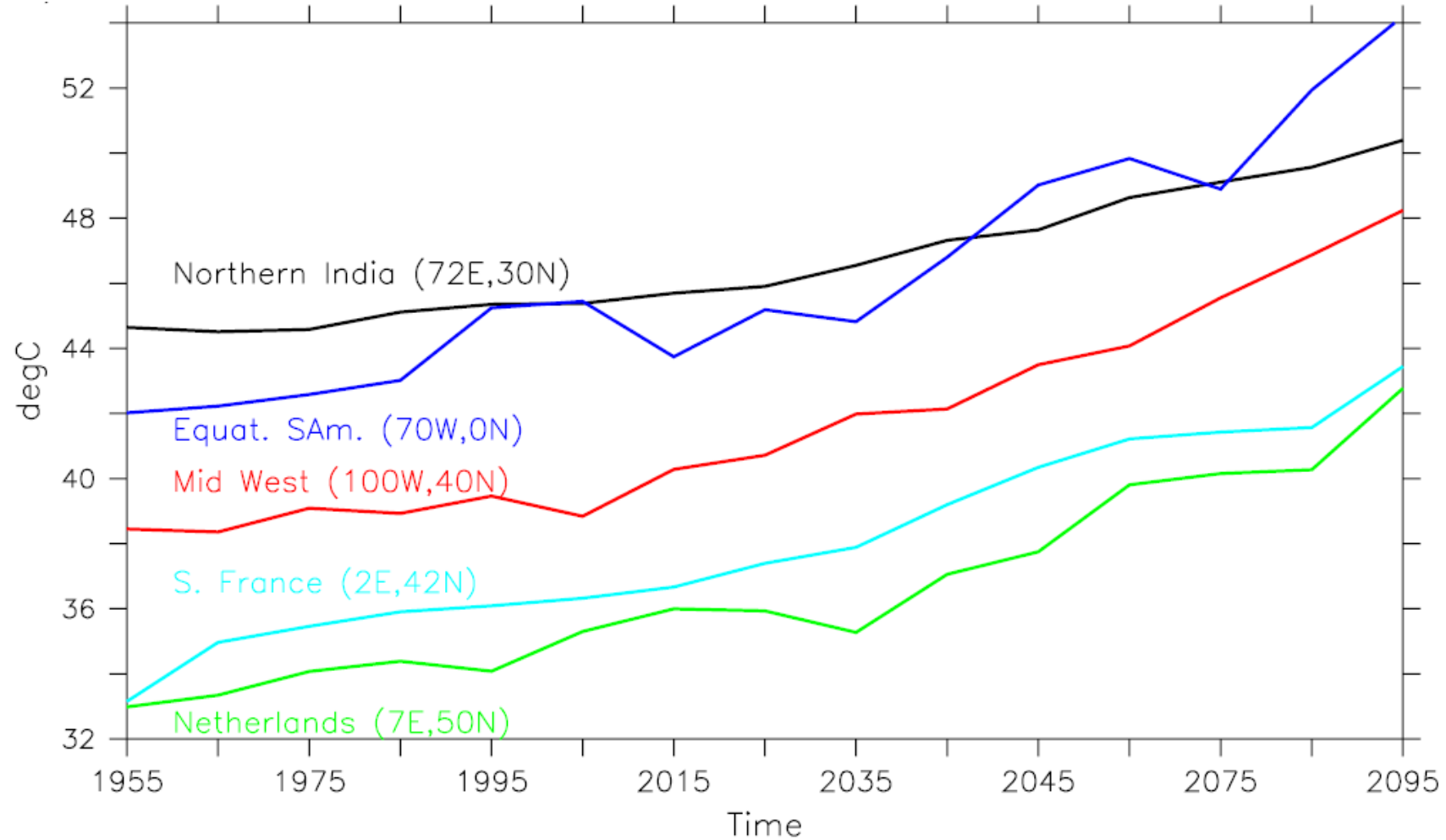
JJA daily "T2m Dp95-Dp50" 2071-2100 vs 1961-1990 (RCMs)



Exceedances/decade of 1961-90 1/10 warm summers, NH (GCM)



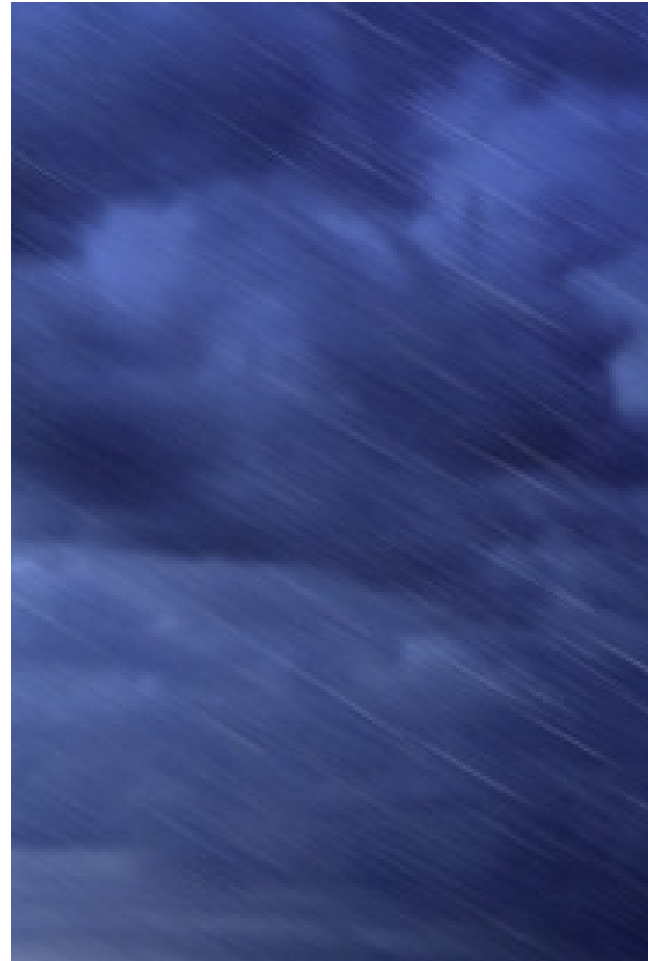
100-year return value of annual-maximum 2m-temperature (GCM)



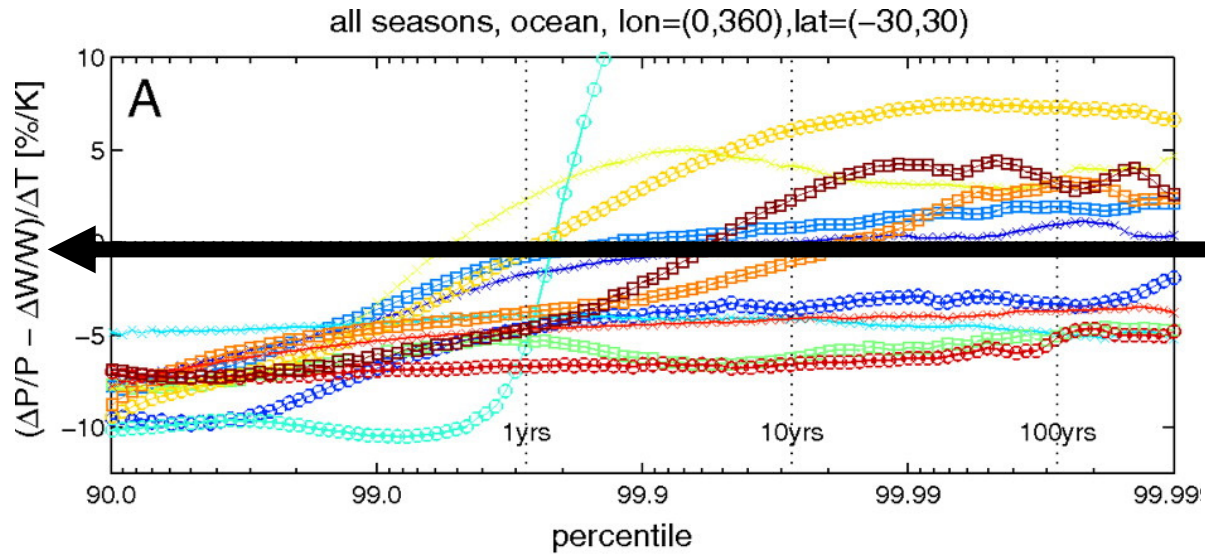
Extremes related to Precipitation

Water in the atmosphere and CC

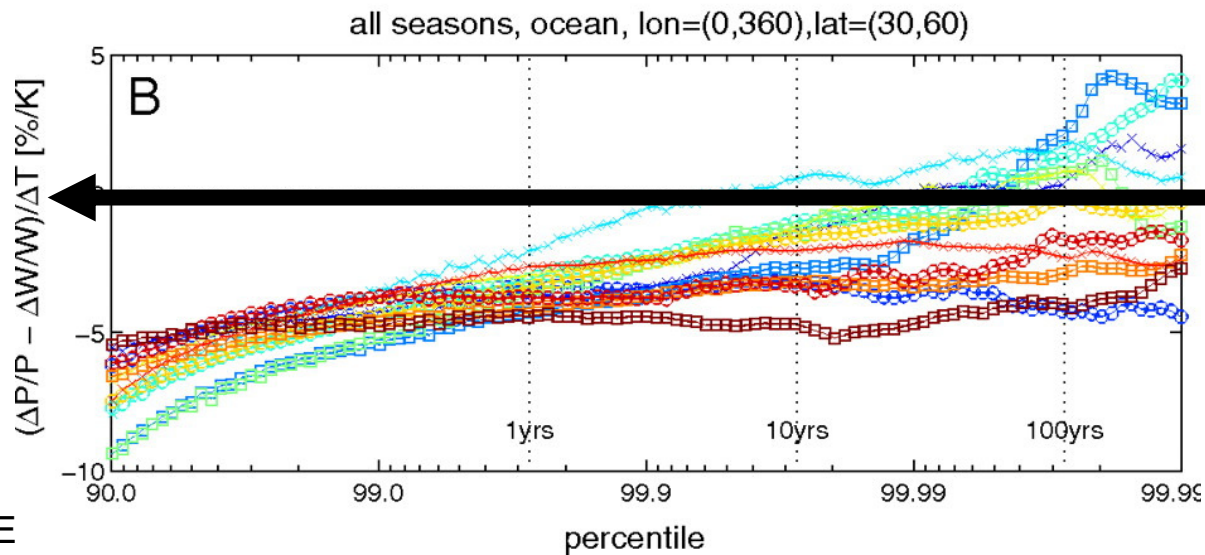
- Precipitable water
~7%/K
- Global mean precip.
~2-3 %/K
- Extreme daily precip.
~6-7%/K
- Extreme hourly precip.
~14%/K (??)



Fractional changes in precip. vs. “moisture” (90th - 99.999th percentiles) (GCMs)



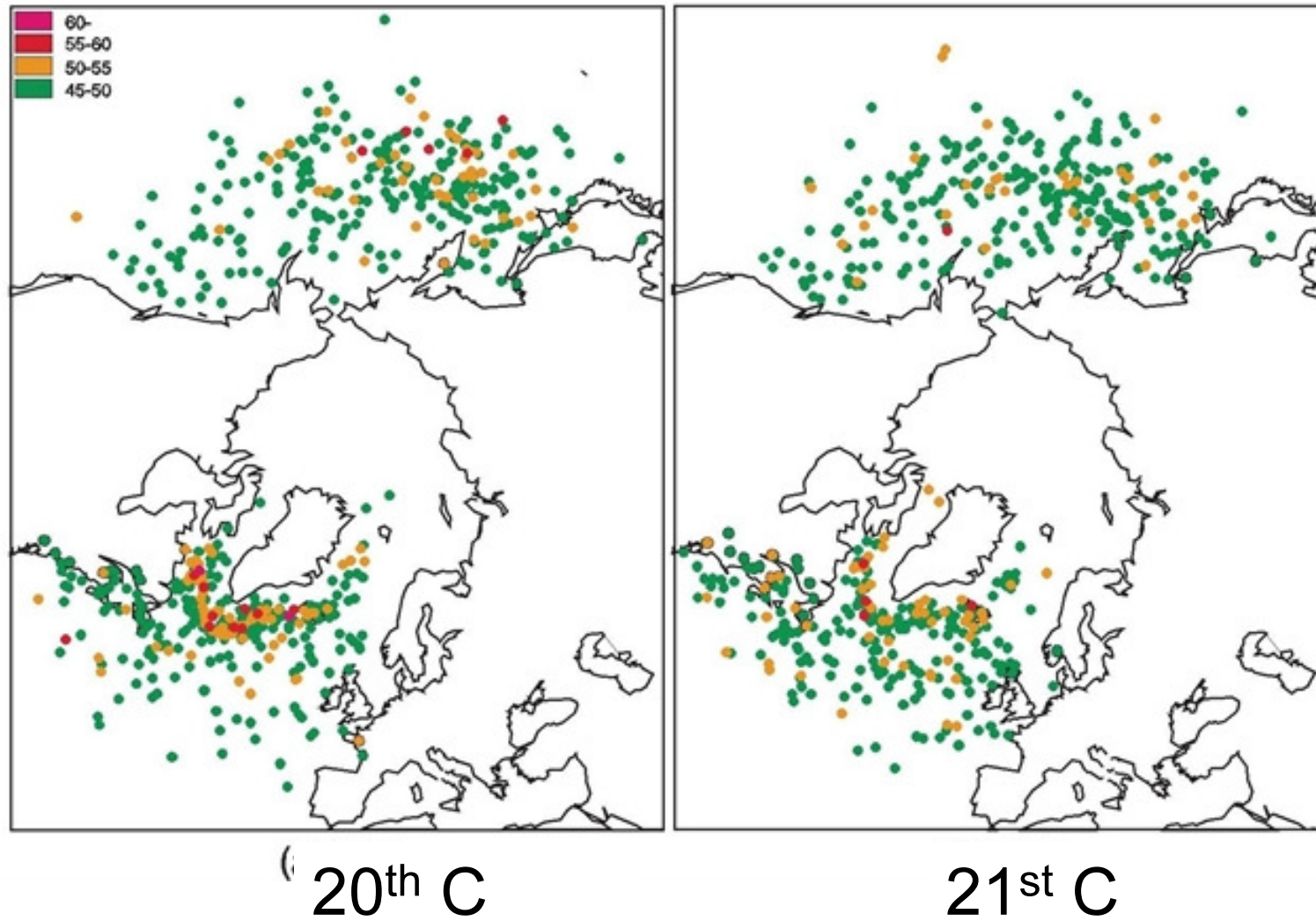
“Tropics”



“Xtratropics”

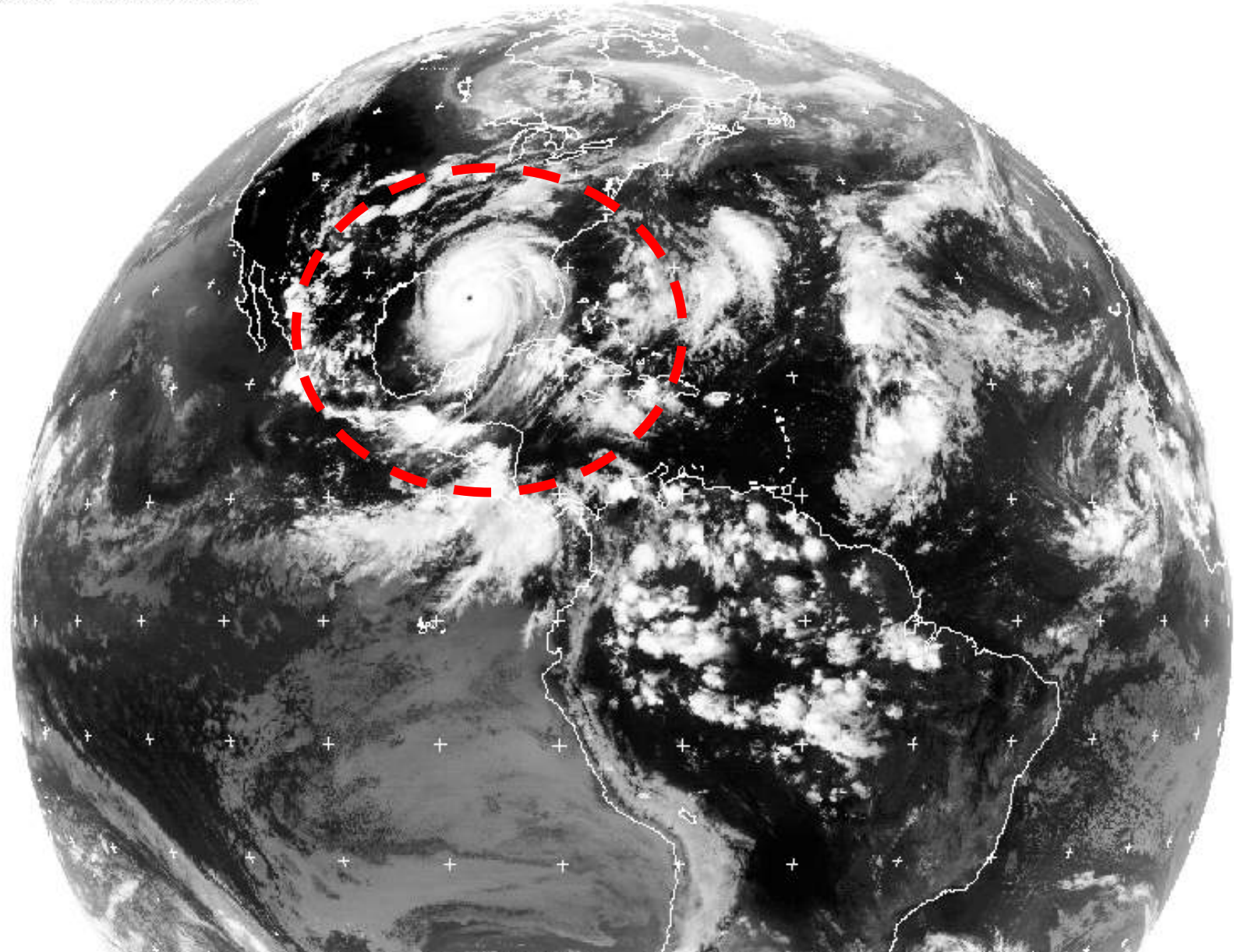
Storms, Extratropical cyclones

Storm tracks (DJF) (GCM)



Storms, Tropical cyclones

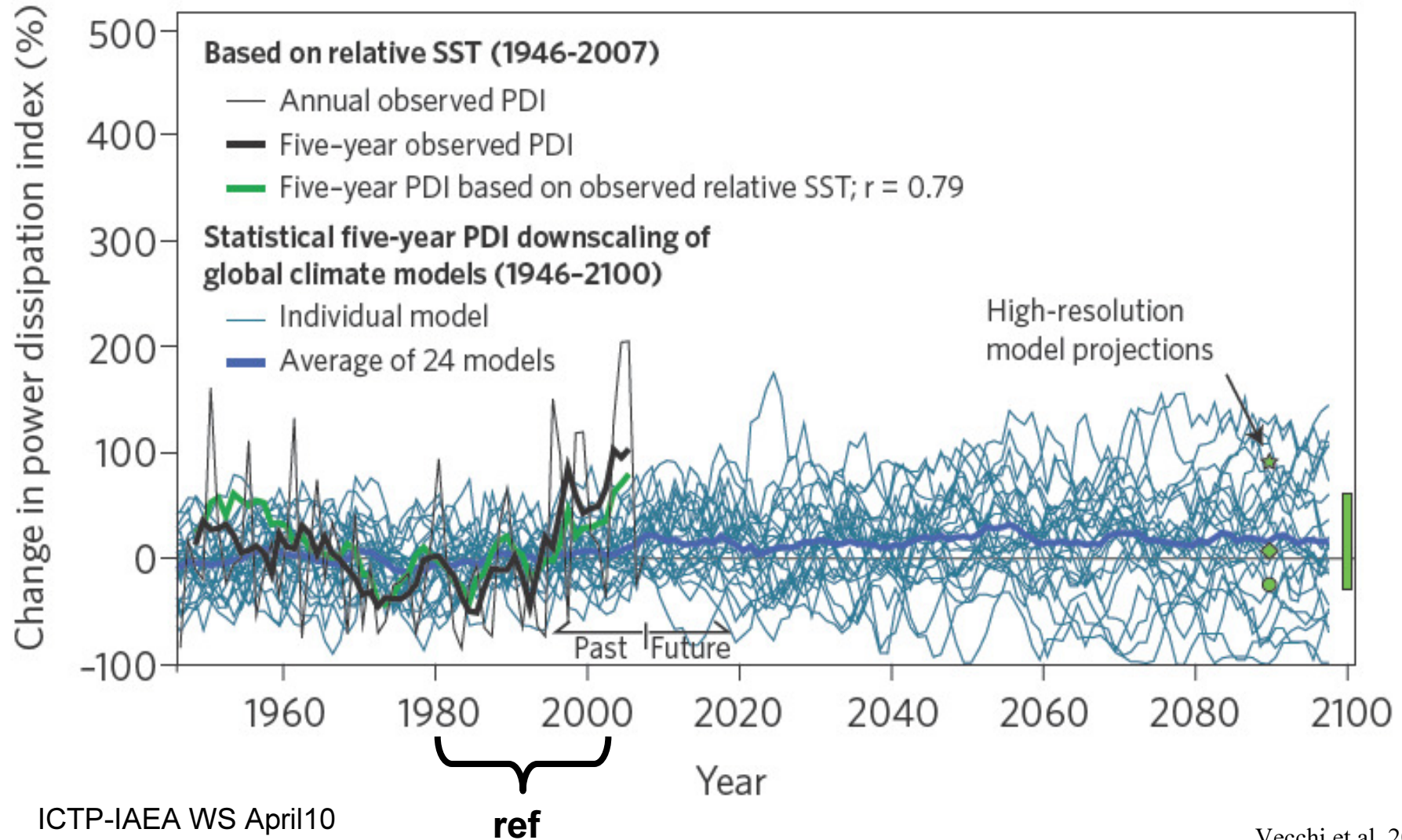
GOES-E IR 00:00 29/08/2005



IC

Atlantic hurricane power (*obs, GCM*)

Based on relative SSTs



Review by Knutson et al. (2010)

(here w/o qualifiers)

- (i) uncertain whether recent tropical cyclone activity exceeds natural variability,
- (ii) CC will not lead to increased global frequency, but that the **frequency of the most intense storms** will increase,
- (iii) some **increase in the maximum wind speeds and rainfall rates**,
- (iv) possible changes in storm formation regions and tropical storm tracks can not be estimated.

Other types of extreme events

- Extreme winds (*GCMs*)
 - Tropics: Frequency generally decreases
 - Extratropics: Frequency generally increases
- Fire
- Tornadoes, thunderstorms, hail, ...



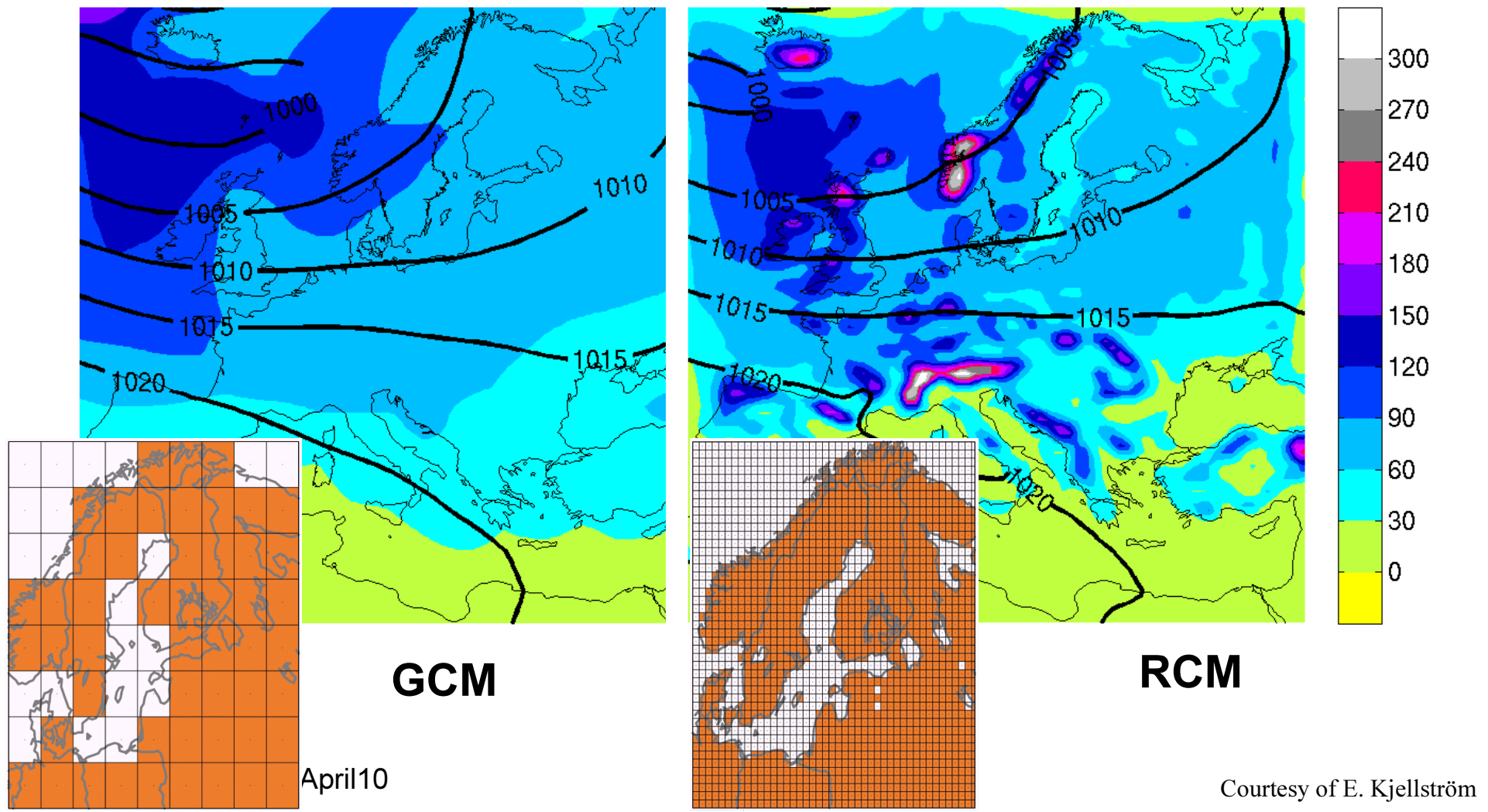
NOAA's National Severe Storms Laboratory (NSSL) Collection

Climate modelling and extremes

- Gridding suppresses extremes
- Model resolution AND physical parameterisations matter
- **Global climate models:** all areas, coarse resolution
- **Regional climate models:** specific areas, higher resolution

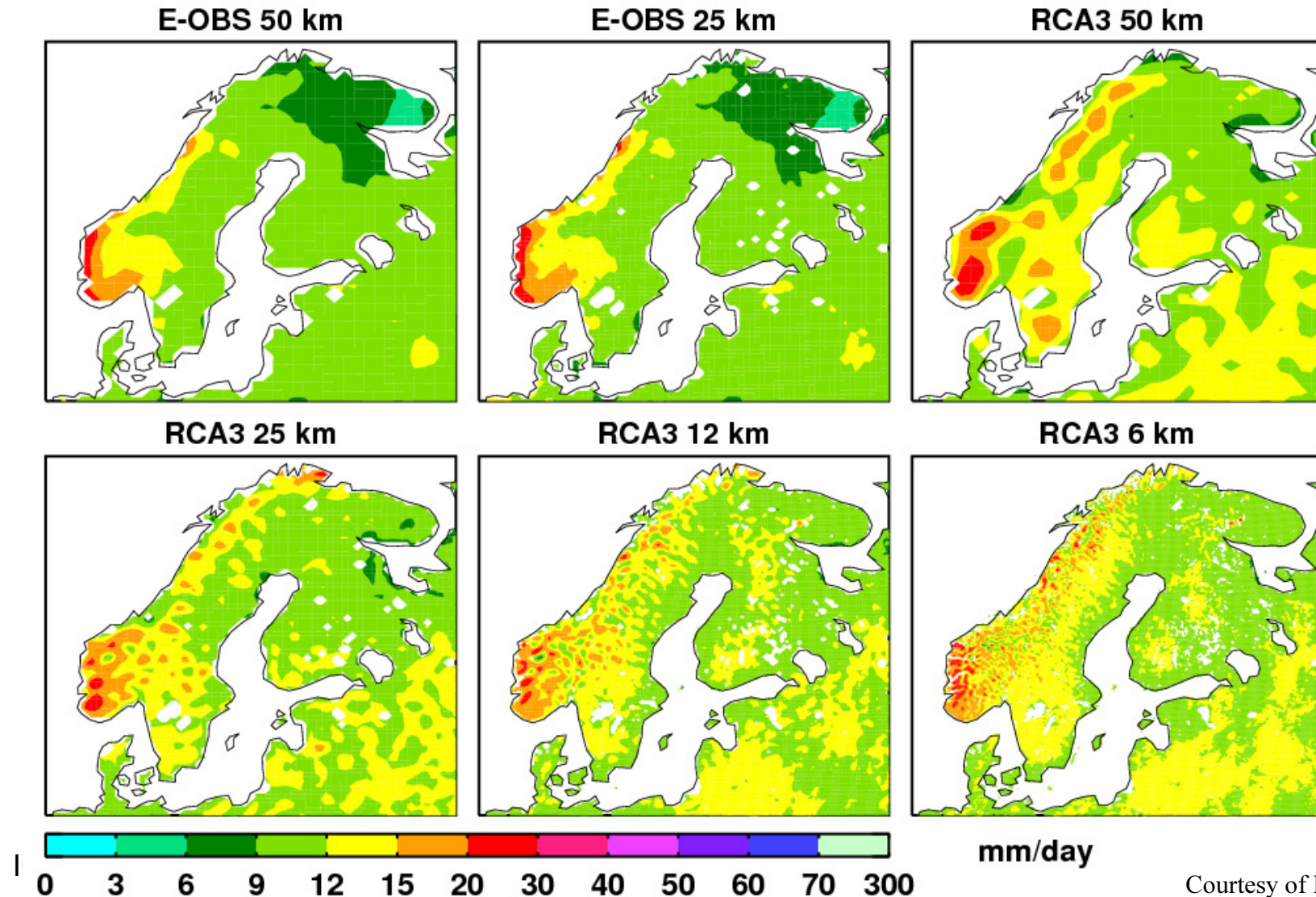
Global and regional climate models...

Simulated DJF MSLP and precipitation (1961-90)



Climate model resolution matters (*RCM*)

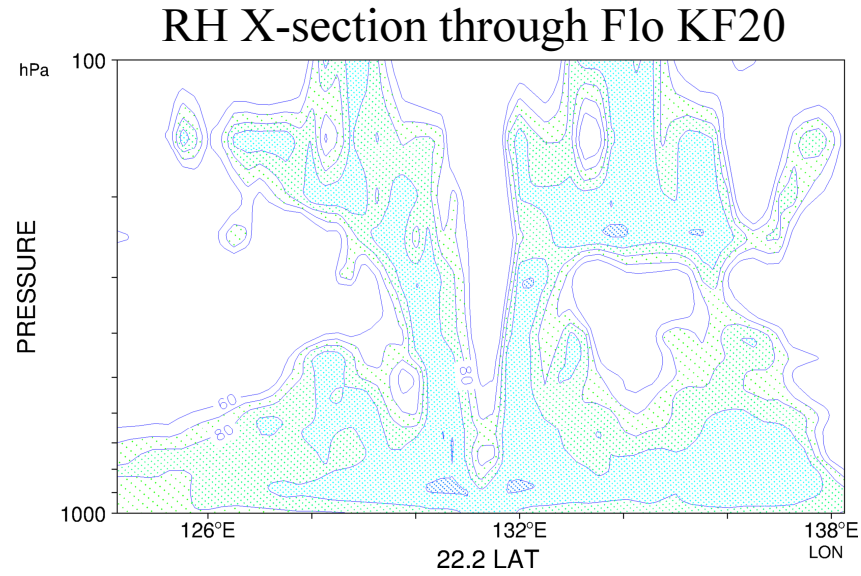
JJA precip, 95th percentile 1987-2007



Courtesy of E. Kjellström

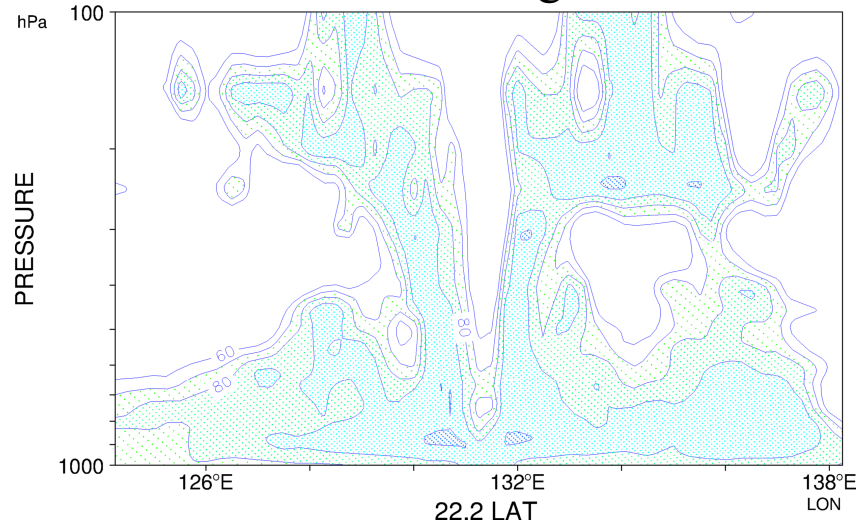
Simulated typhoon (*RCM*)

KF at 20 km



Simulated typhoon

RH X-section through Flo KF20



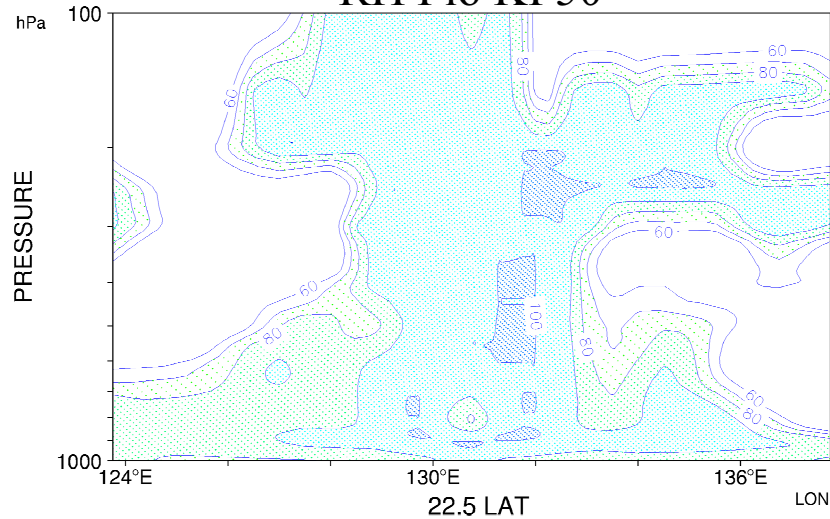
KF at 20 km



KF at 50 km

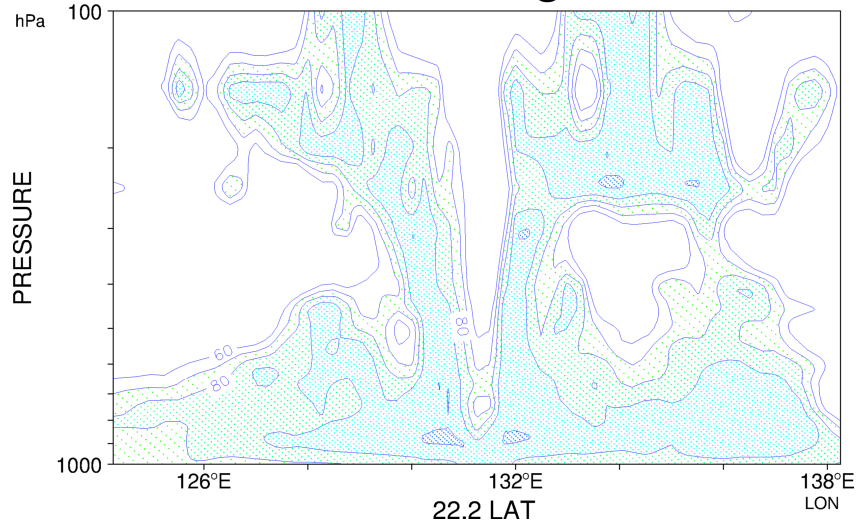


RH Flo KF50



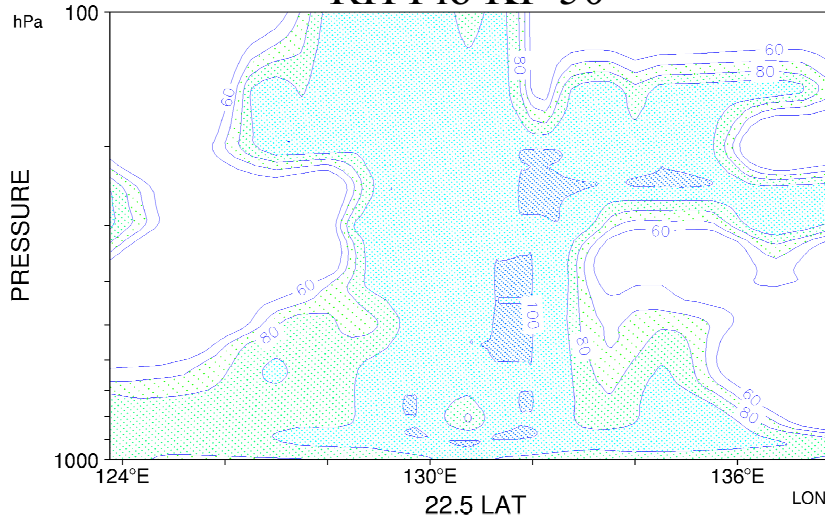
Simulated typhoon: Resol & Parameterisations

RH X-section through Flo KF 20



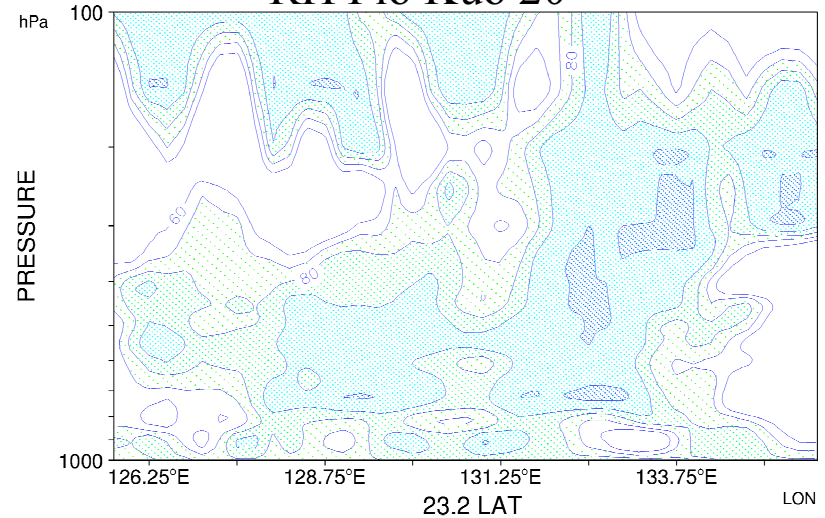
KF at 50 km

RH Flo KF 50



Kuo at 20 km.

RH Flo Kuo 20



Some important uncertainties

- Changes in extreme winds
- Changes in tropical and extratropical storm frequencies / total numbers
- In various aspects of extreme events that have not been assessed comprehensively
- Small-scale extreme events

Some key robust findings

- More warm extremes
- Fewer cold extremes
- Precipitation extremes increase more than average precipitation
- Increasing winds and heavy precipitation in storms
- Poleward shift of extratropical storm tracks