Water vapor and <M.S.E.> budgets

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Moisture equation

$$\frac{\partial \overline{q}}{\partial t} = ADV_q - div(\overline{\omega' q'}) - C$$

Molecular at surface
Eddy flux above...

MSE equation eliminates Cond.

$$L\left(\frac{\partial \overline{q}}{\partial t} = ADV_q - div(\overline{\omega' q'}) + C\right.$$

$$+C_p\frac{\partial \overline{T}}{\partial t} = C_p ADV_T - C_p div(\overline{\omega' T'} + F_r) \quad LC$$

$$\frac{\partial \overline{h}}{\partial t} = ADV_h - div(\overline{\omega' h'} + F_r)$$

Vertical integral <> eliminates profile

$$\frac{\partial < \overline{h} >}{\partial t} = < ADV_h > + F_s + R_{net}$$

Time averaging eliminates causality

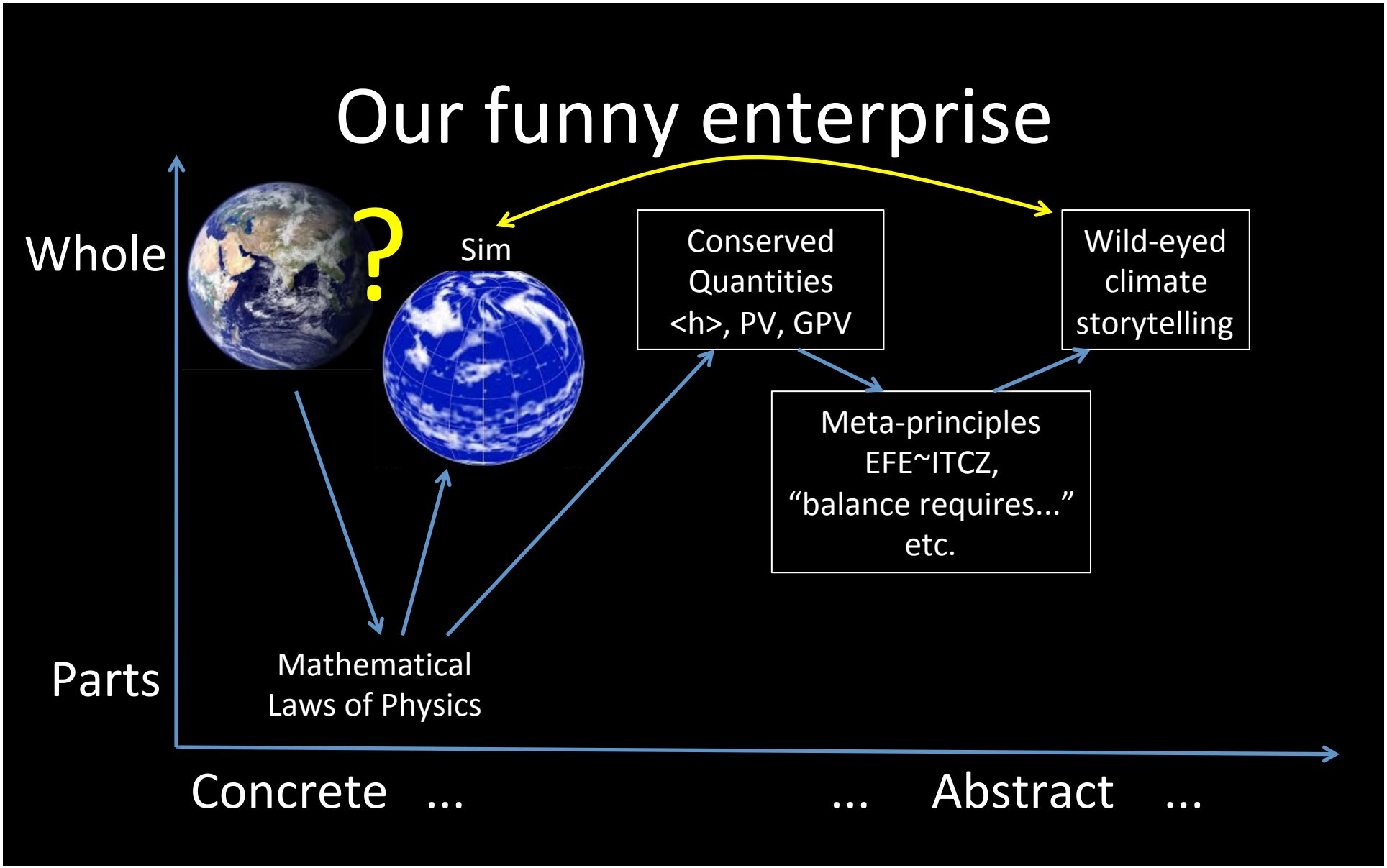
$$0 = < ADV_h > + F_s + R_{net}$$

Now, let's use it

- to predict causes of rain belts (net Cond.) and their contrasting profiles over land & sea!

- Well, not quite absurd perhaps...

Our funny enterprise



Back to moisture – but wiser

$$< h' > \approx L < q' >$$

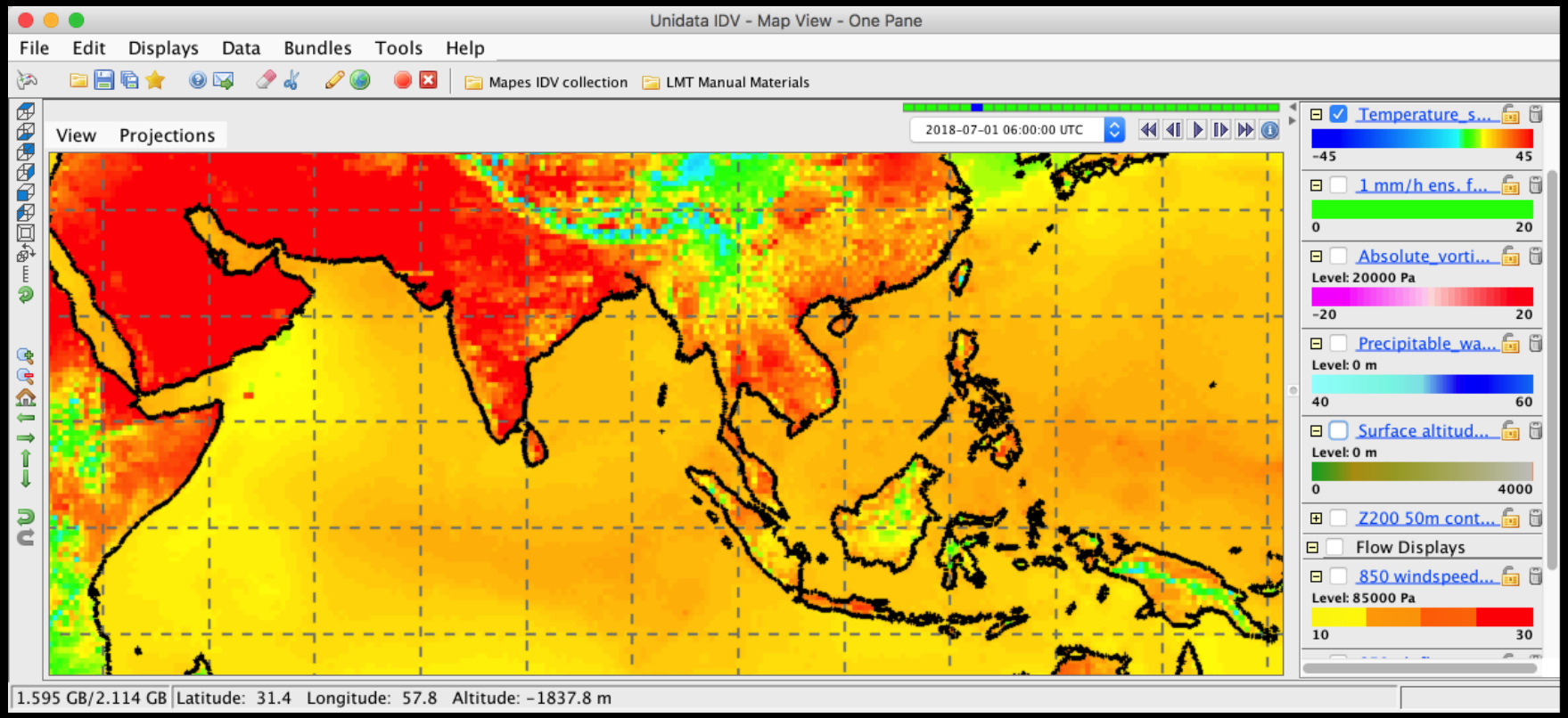
Well measured
by microwave!
(over water)

Connects to a practically important
but dynamically wooly field
called hydrology...

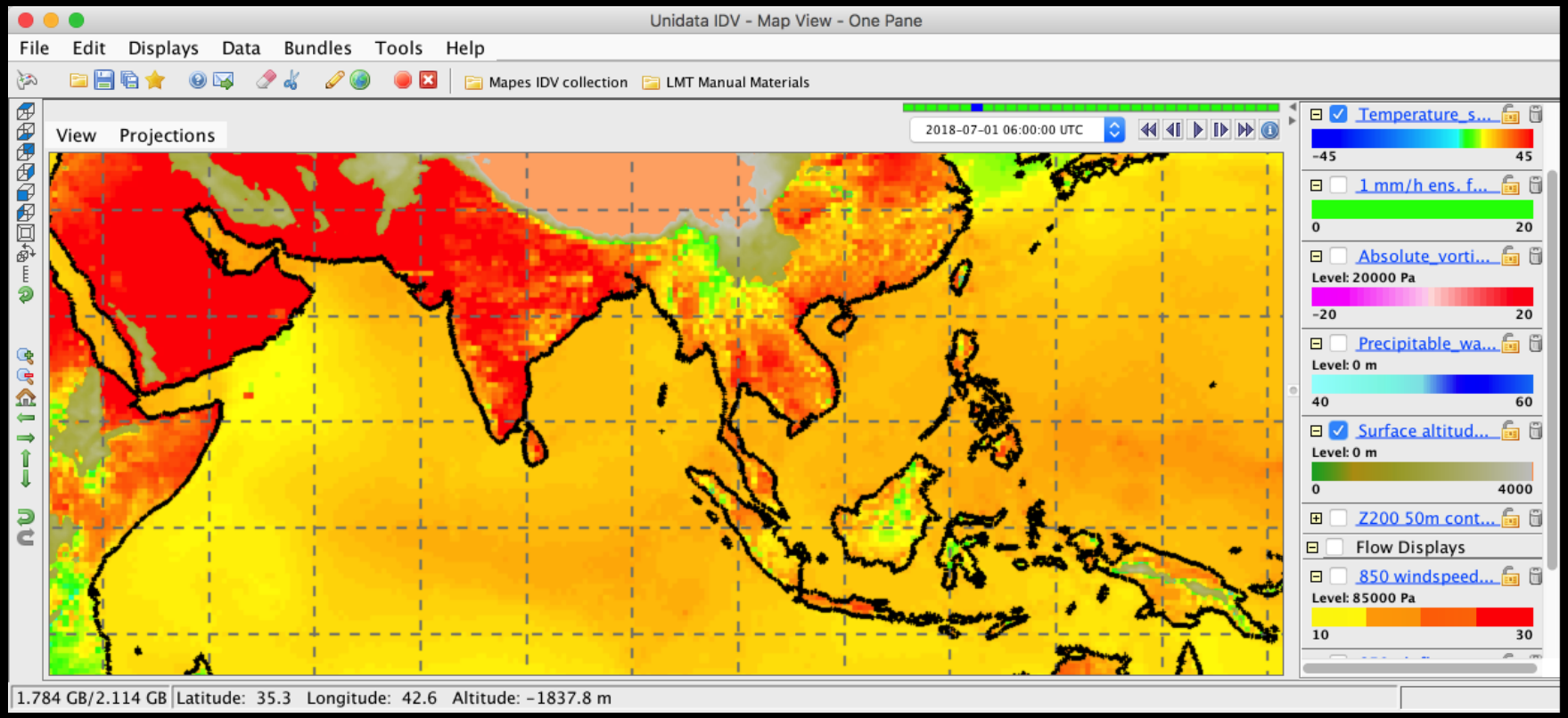
Let’s look at some data

- Well measured → well analyzed
- Use analyses (and GFS forecast, for fun)

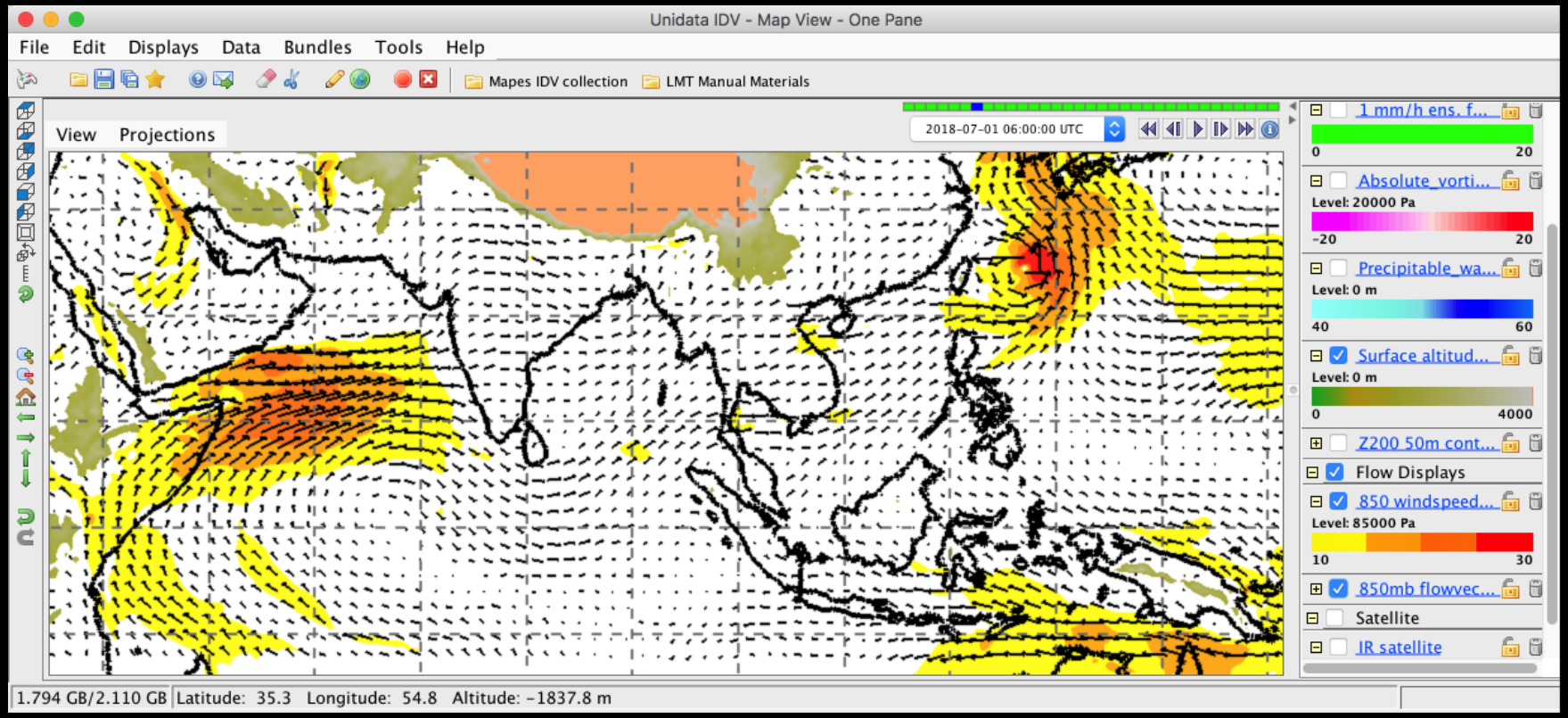
T @surface


Unidata IDV - Map View - One Pane
File Edit Displays Data Bundles Tools Help
Mapes IDV collection
LMT Manual Materials
View Projections
2018-07-01 06:00:00 UTC
Temperature_s...
-45 45
1 mm/h ens. f...
0 20
Absolute_vorti...
Level: 20000 Pa
-20 20
Precipitable_wa...
Level: 0 m
40 60
Surface altitud...
Level: 0 m
0 4000
Z200 50m cont...
Flow Displays
850 windspeed...
Level: 85000 Pa
10 30
1.595 GB/2.114 GB
Latitude: 31.4 Longitude: 57.8 Altitude: -1837.8 m

Topography >1500m



V850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2018-07-01 06:00:00 UTC
1 mm/h ens. f...
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Absolute_vorti...
Level: 20000 Pa
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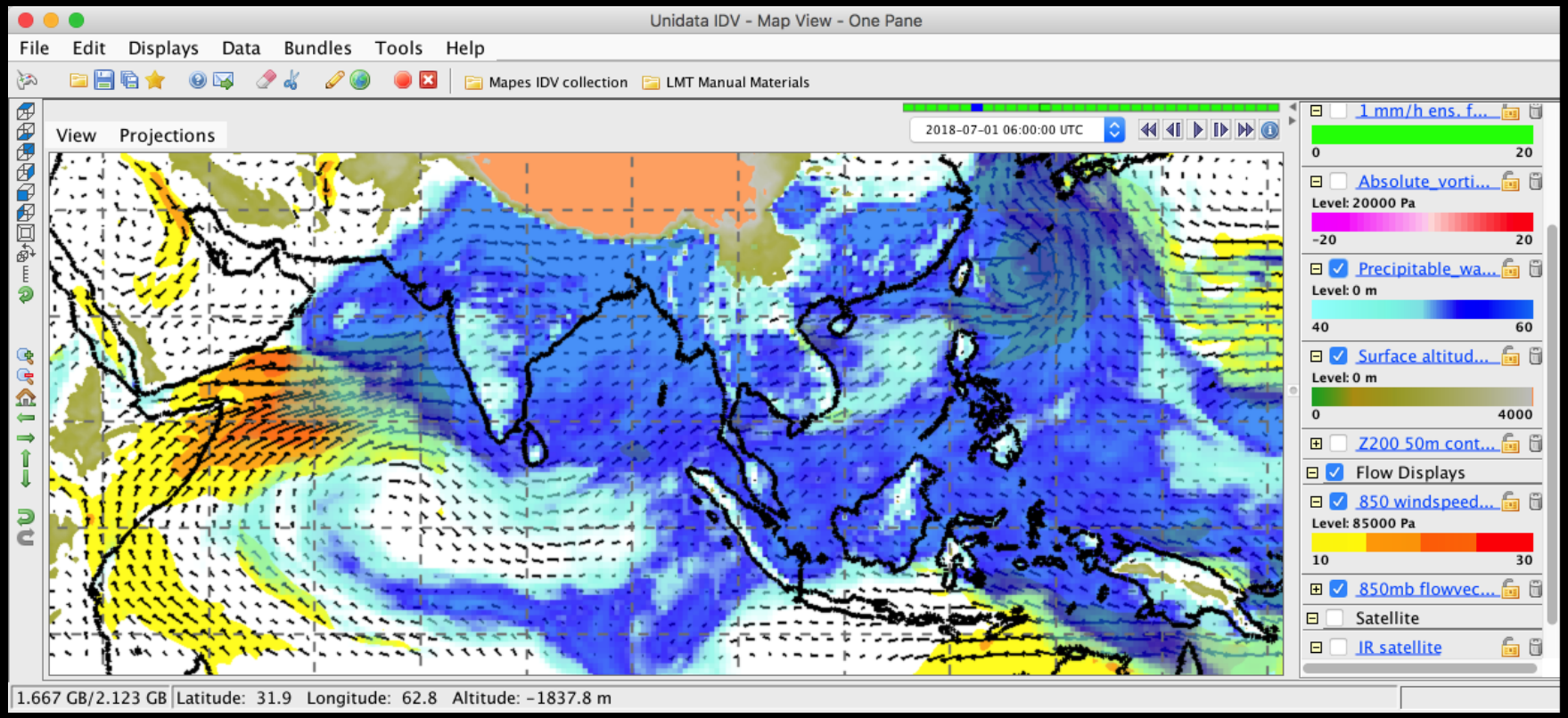
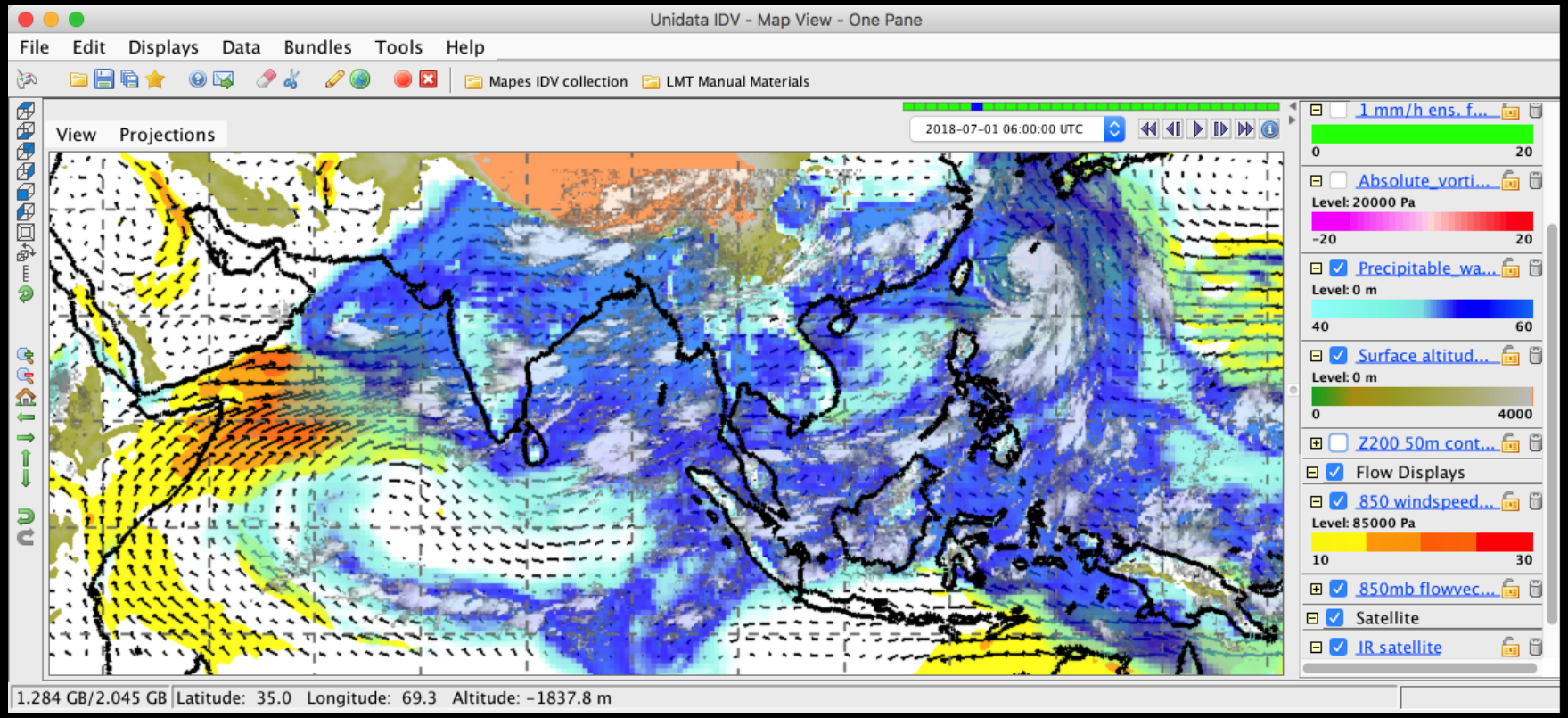
20
Precipitable_wa...
Level: 0 m
40
60
Surface altitud...
Level: 0 m
0
4000
Z200 50m cont...
Flow Displays
850 windspeed...
Level: 85000 Pa
10
30
850mb flowvec...
Satellite
IR satellite
1.794 GB/2.110 GB
Latitude: 35.3
Longitude: 54.8
Altitude: -1837.8 m

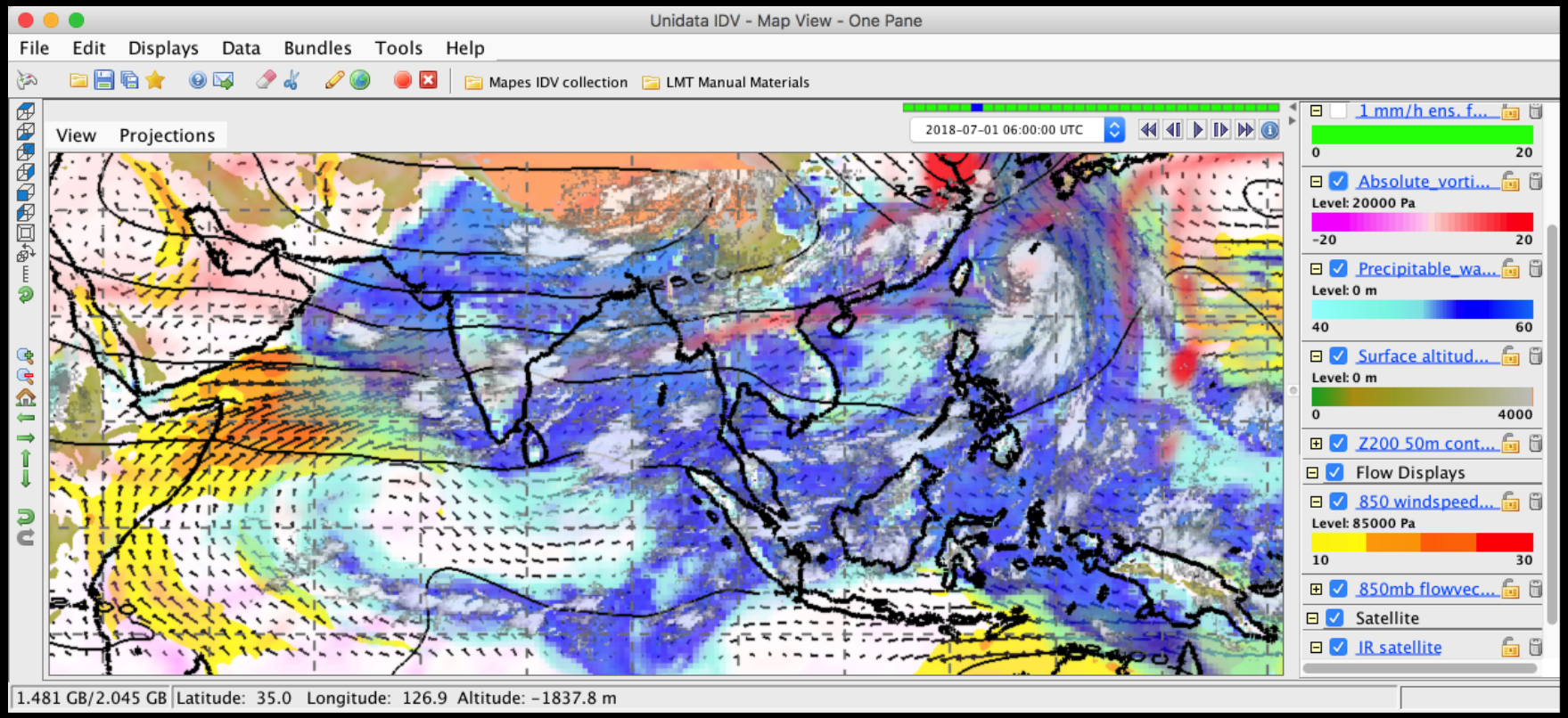
<q>, steep color @50mm



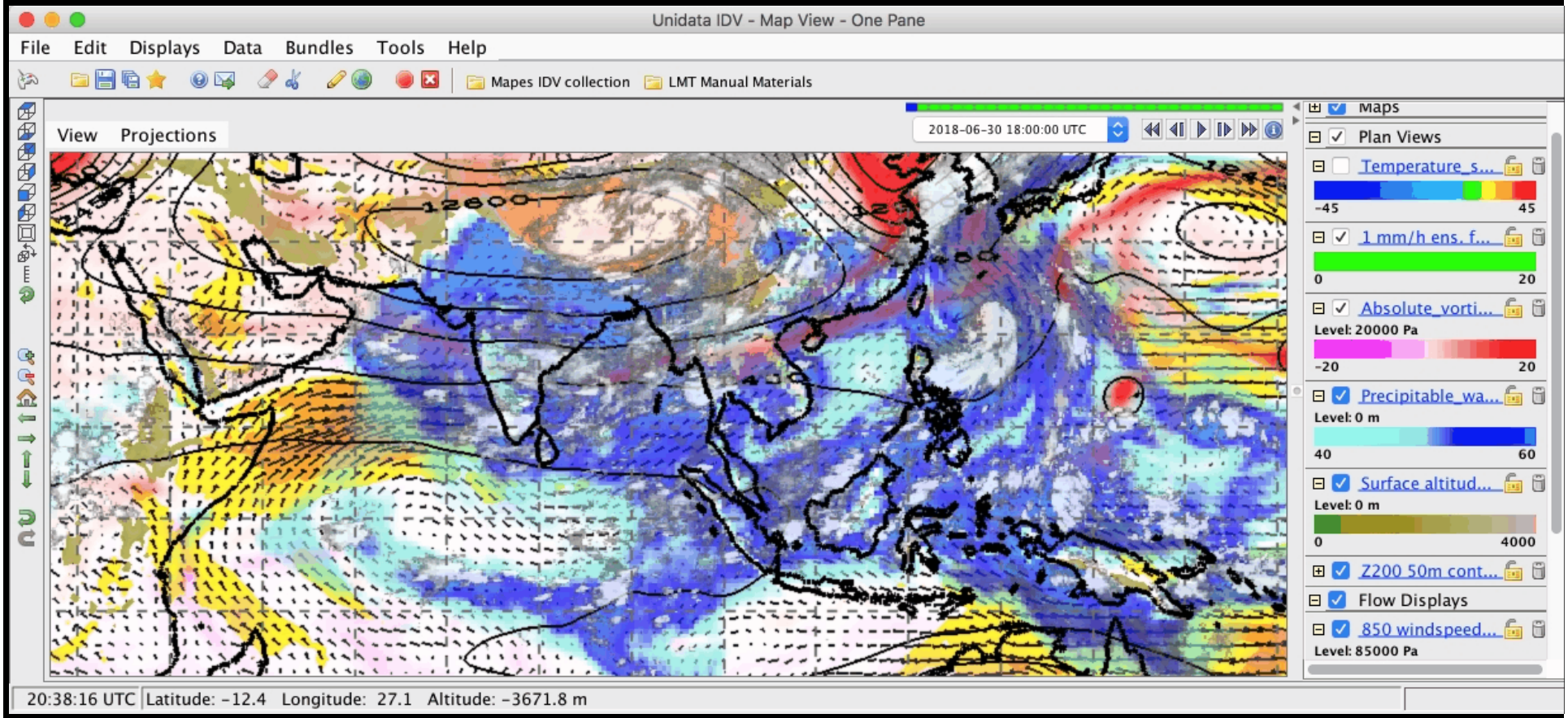
Deep convection tightly contained



Z200 and ζ200



Go!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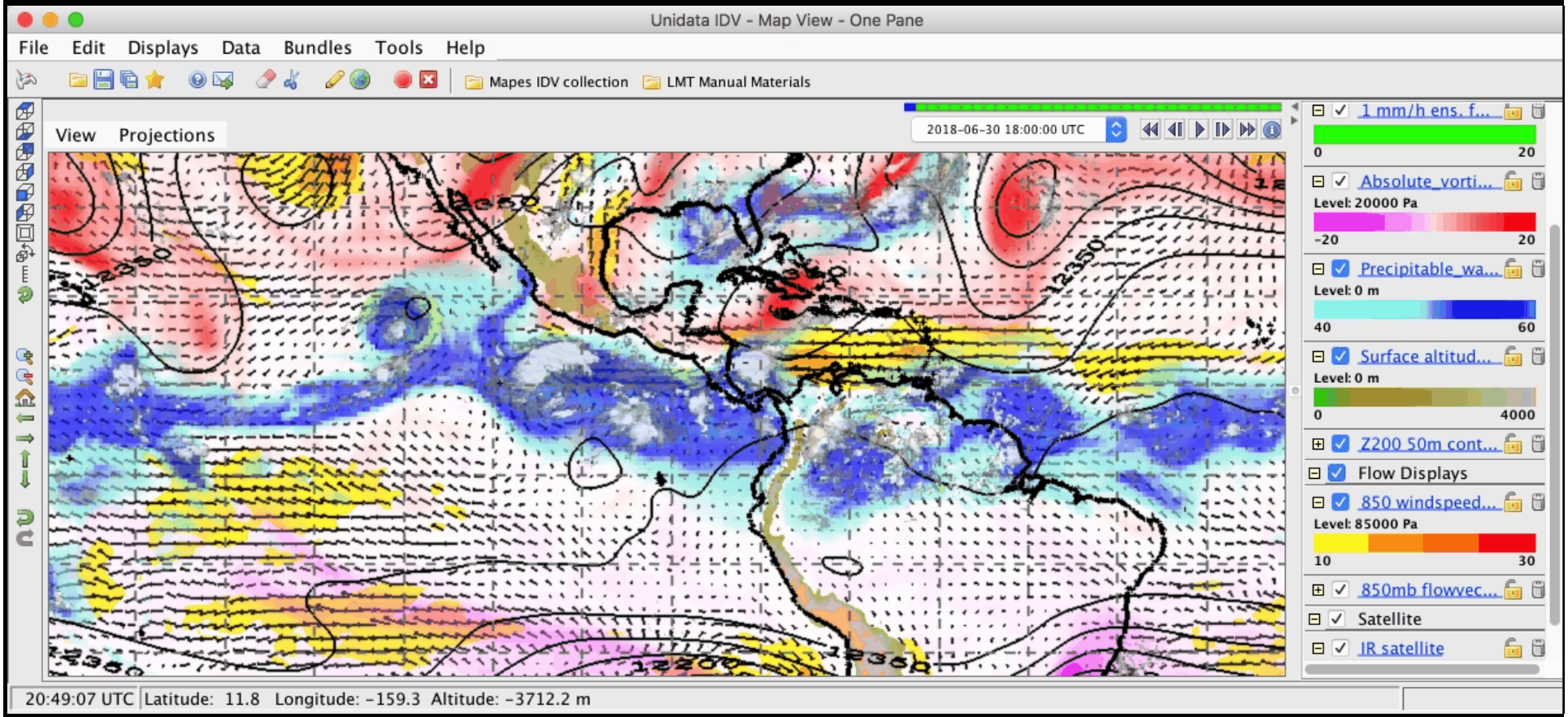
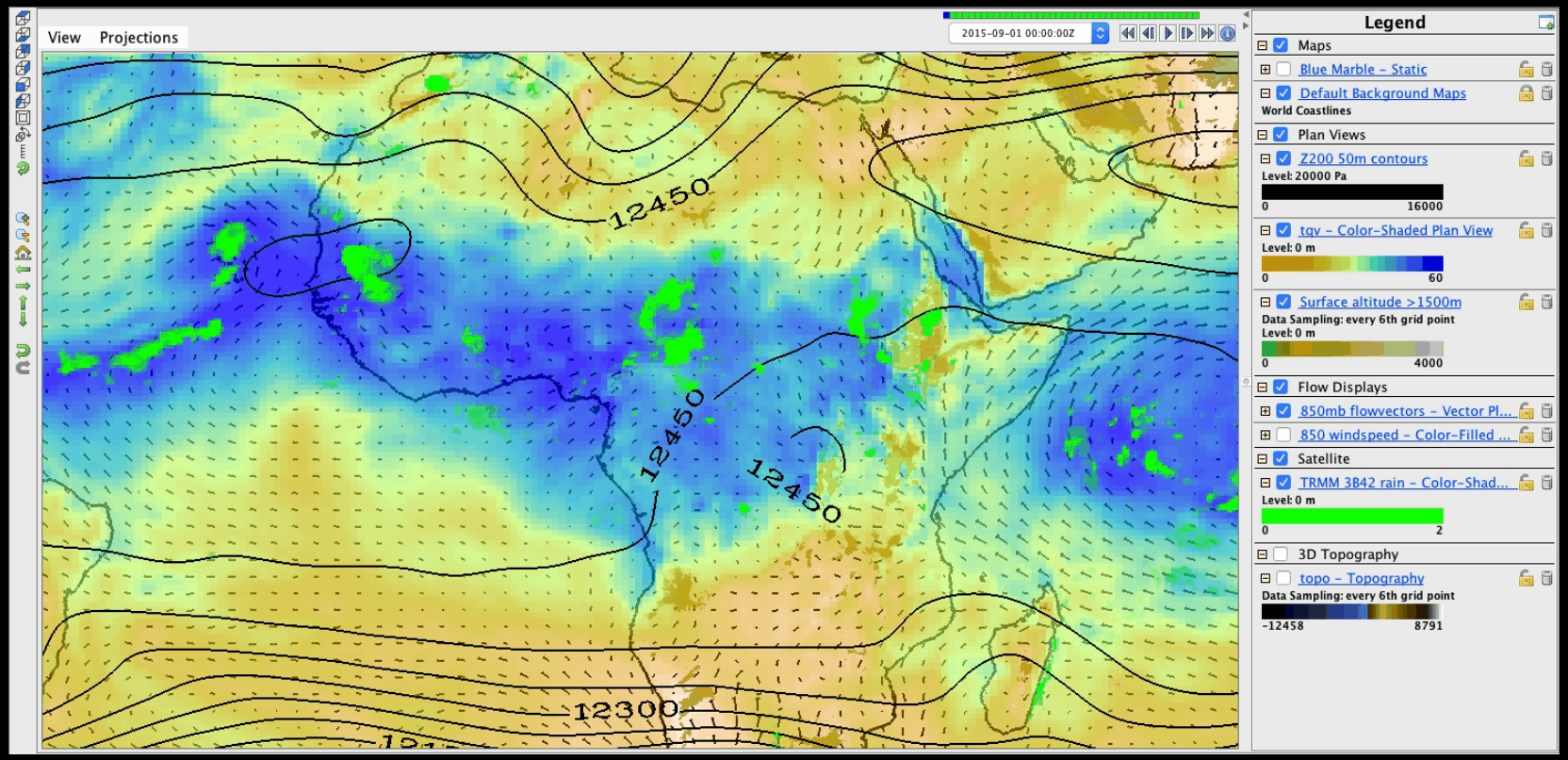
2018-06-30 18:00:00 UTC
Maps
Plan Views
Temperature_s...
-45 45
1 mm/h ens. f...
0 20
Absolute_vorti...
Level: 20000 Pa
-20 20
Precipitable_wa...
Level: 0 m
40 60
Surface altitud...
Level: 0 m
0 4000
Z200 50m cont...
Flow Displays
850 windspeed...
Level: 85000 Pa
20:38:16 UTC Latitude: -12.4 Longitude: 27.1 Altitude: -3671.8 m

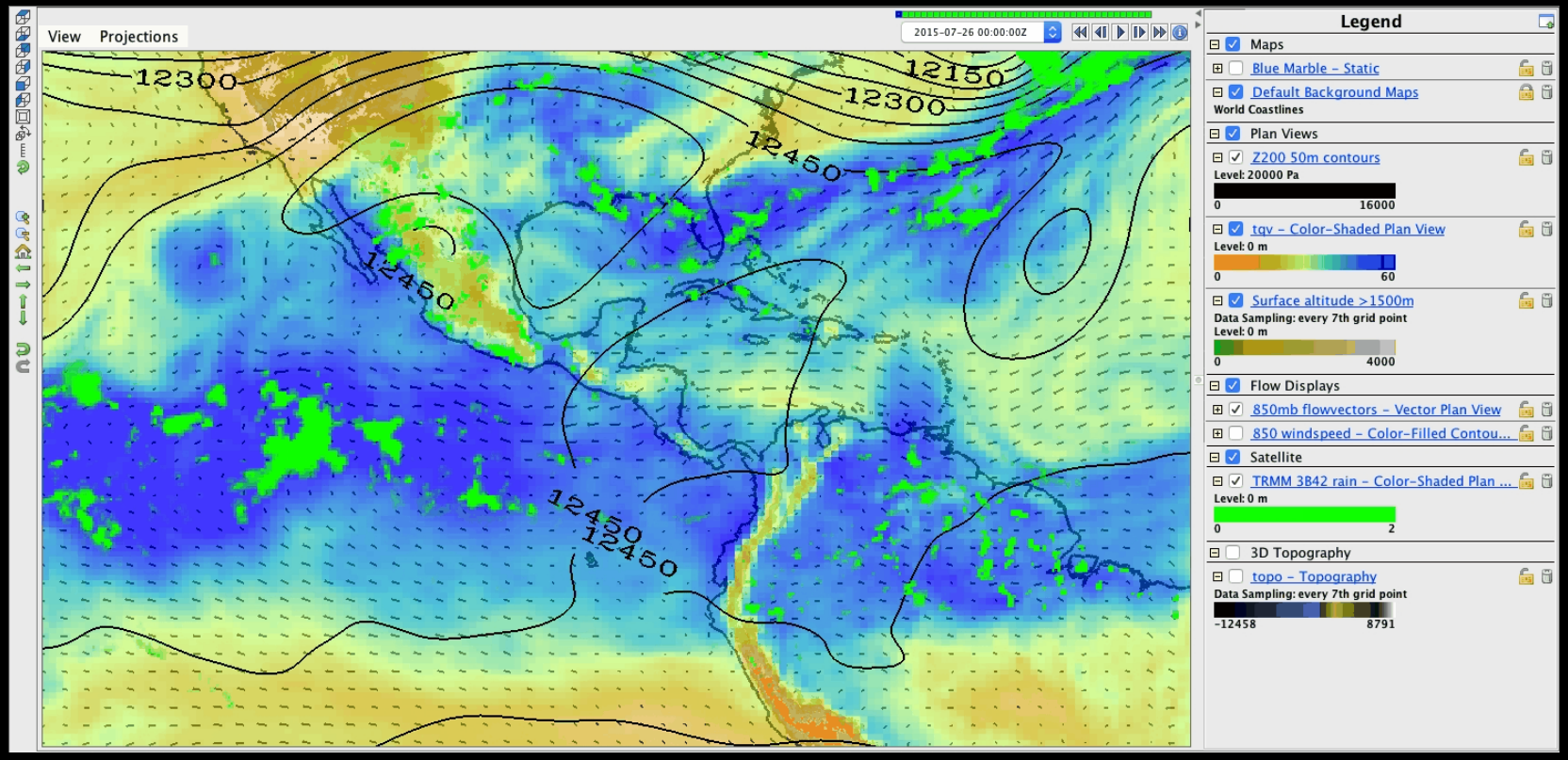
Americas sector



Africa, September (green=rain)



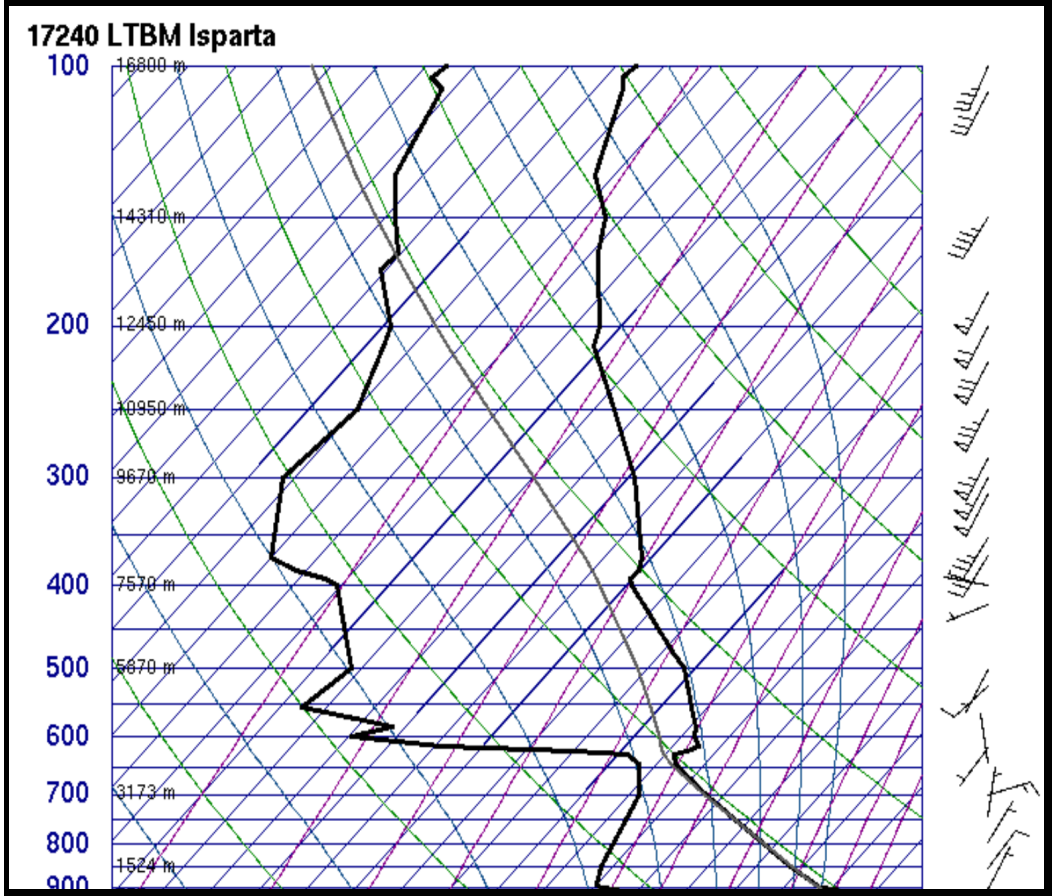
Americas, September (green=rain)



What did we see?

- <q> = <MSE> features travel 1000s of km
- [u]<0 sweeps everything westward
  - Feedback: Asian monsoon u*v* → westward <[u]>
    - » Kelly and Mapes papers (2012-2014)
- Features amazingly long-lived... *maintenance*?

Aside: Kelly PhD: *one sounding* can index Tibetan High's u*v*!



u*v* → westward <[u]>

Geophysical Research Letters

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Research Letter

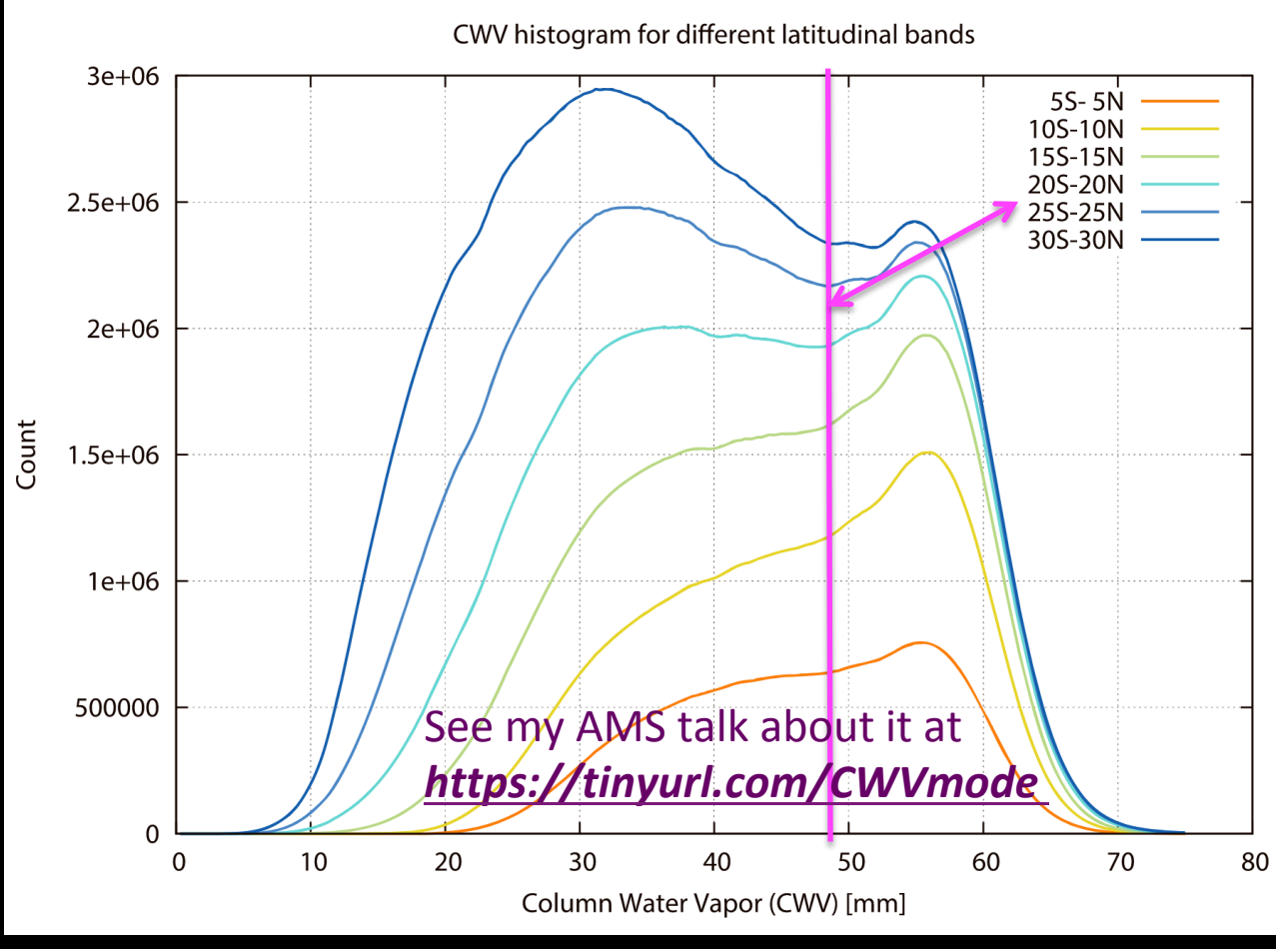
The Meandering Margin of the Meteorological Moist Tropics

Brian E. Mapes ✉, Eui Seok Chung, Walter M. Hannah, Hirohiko Masunaga, Anthony J. Wimmers, Christopher S. Velden

First published: 17 January 2018 | https://doi.org/10.1002/2017GL076440

"Meteorological Moist Tropics": a *regime* (mode of a PDF)

- Margin is ~48mm in current climate (globally)
  - CWV/CWV_{sat} ~75%, more fundamentally
- *Maintenance is occurring*
  - a distinct role for convection...

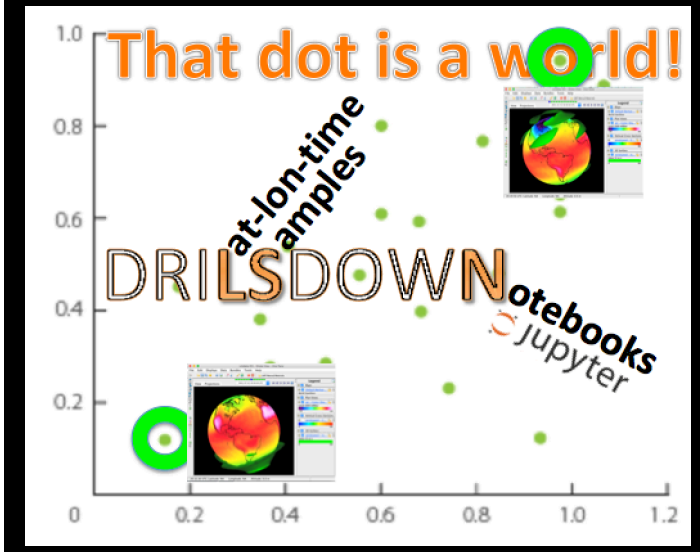


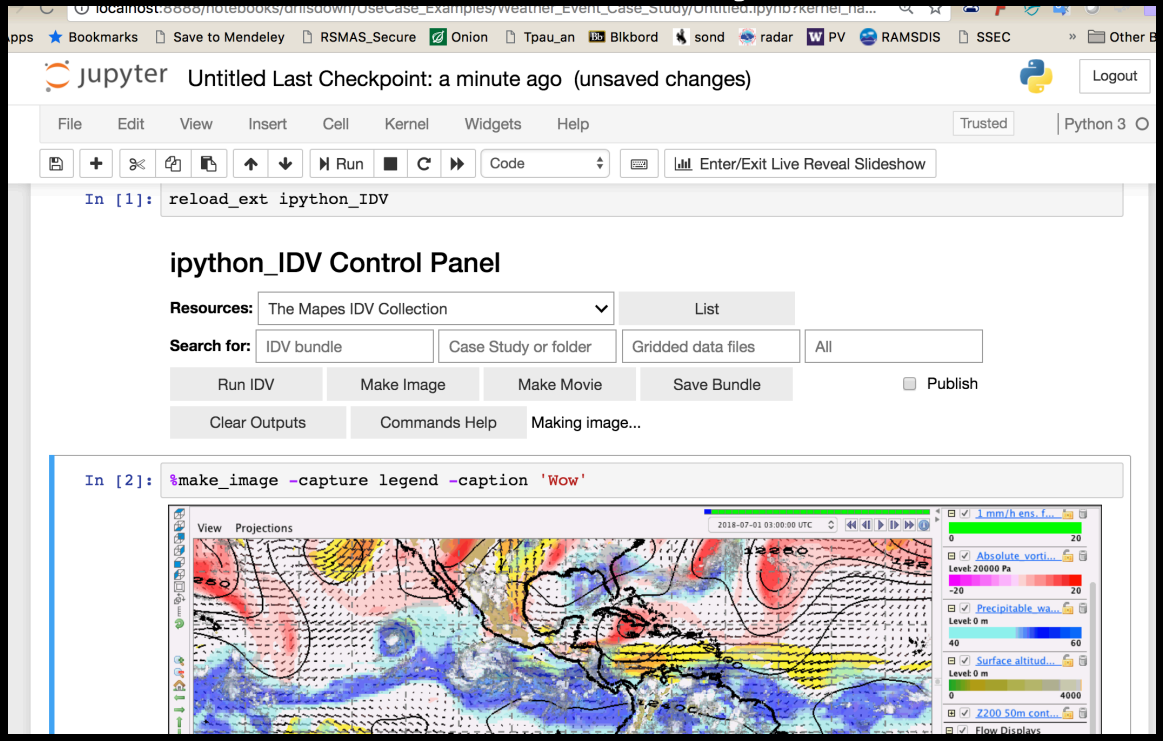
AMS Meandering Margin talk

- *https://tinyurl.com/CWVmode*
- video and slides

high-information Case Study tool

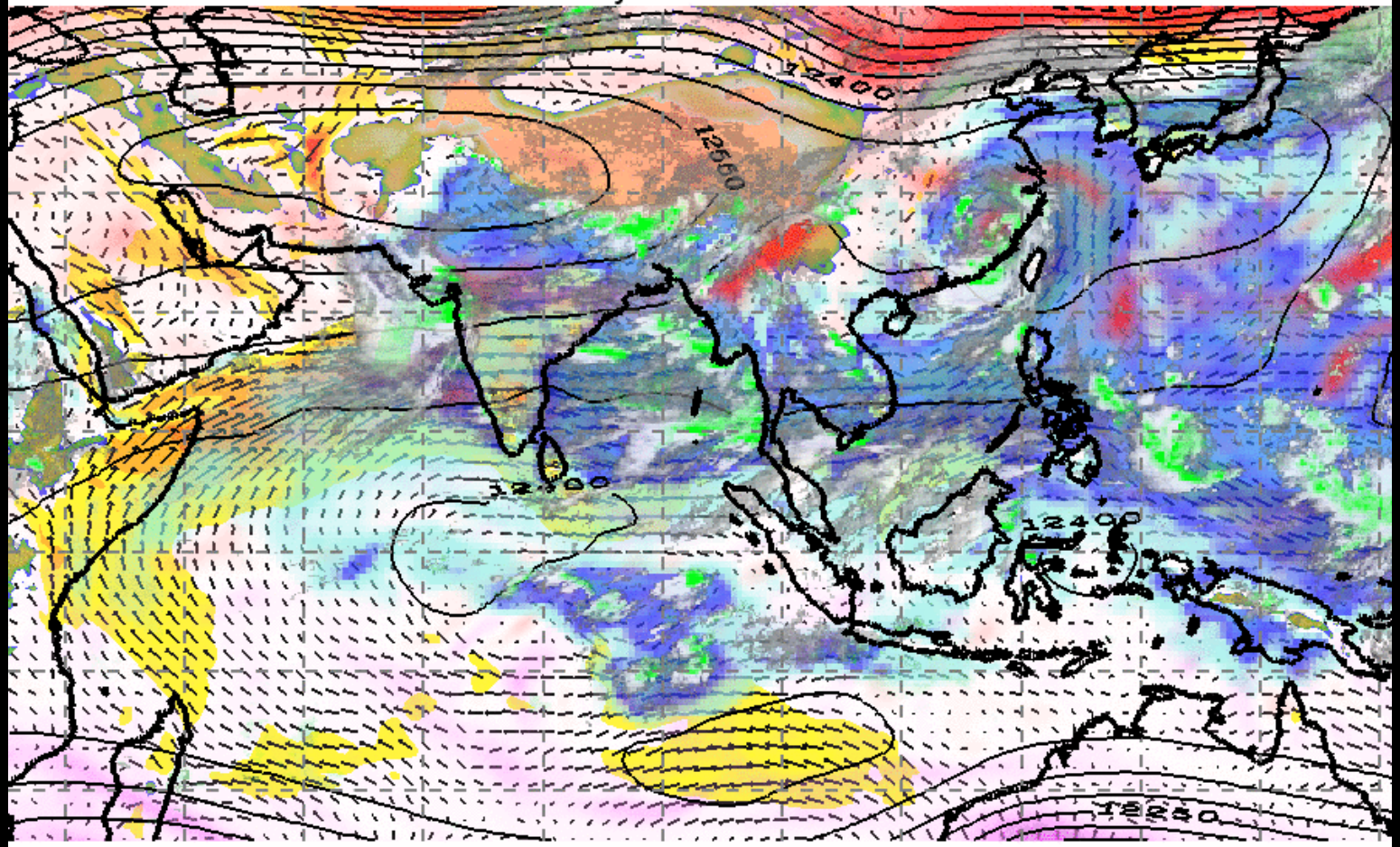
- "Drill down"
  - stats←→ cases
- Jupyter + IDV
- From templates





unidata.github.io/drilsdown

GFS 2014 July 23 21 H UTC -9H lead



20 1.0E-5 s-1 | 0 1.0E-5 s-1 | 20 1.0E-5 s-1
Absolute Vorticity

40 mm | 50 mm | 60 mm
Precipitable Water

1500 gpm | 2750 gpm | 4000 gpm
Surface Height

10 m/s | 20 m/s | 30 m/s
Wind Speed (850hPa)

0 | 5 | 10
TRMM rain/GFS rain

220 K | 250 K | 280 K
Infrared Temperature