

Decadal trends in convection from satellite microwave observations of near-surface wind and deep clouds

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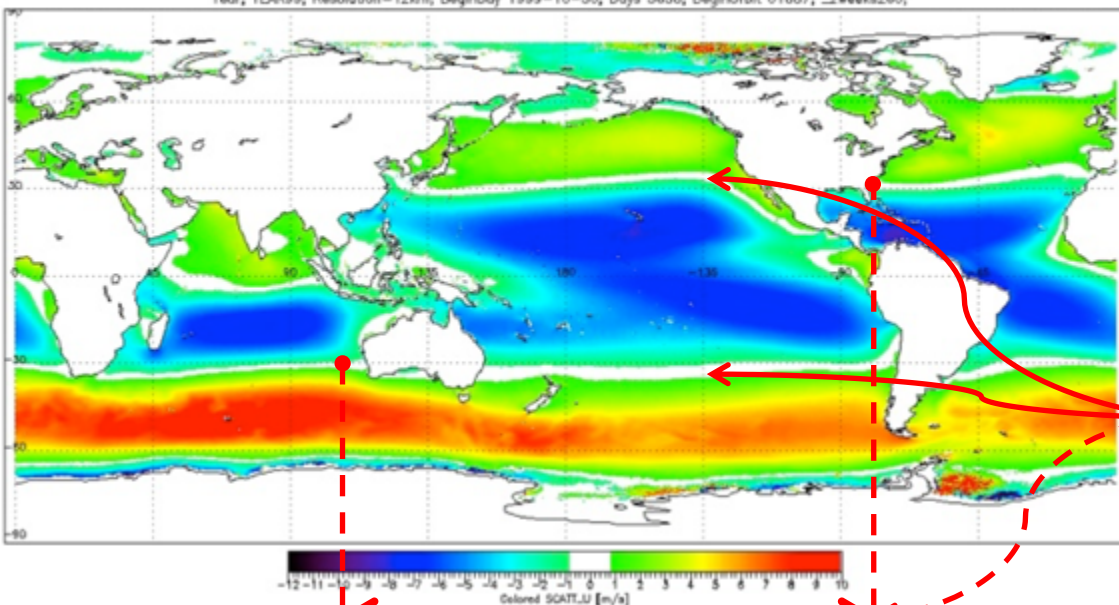
Climate question:

Evolution of
the Hadley
circulation?

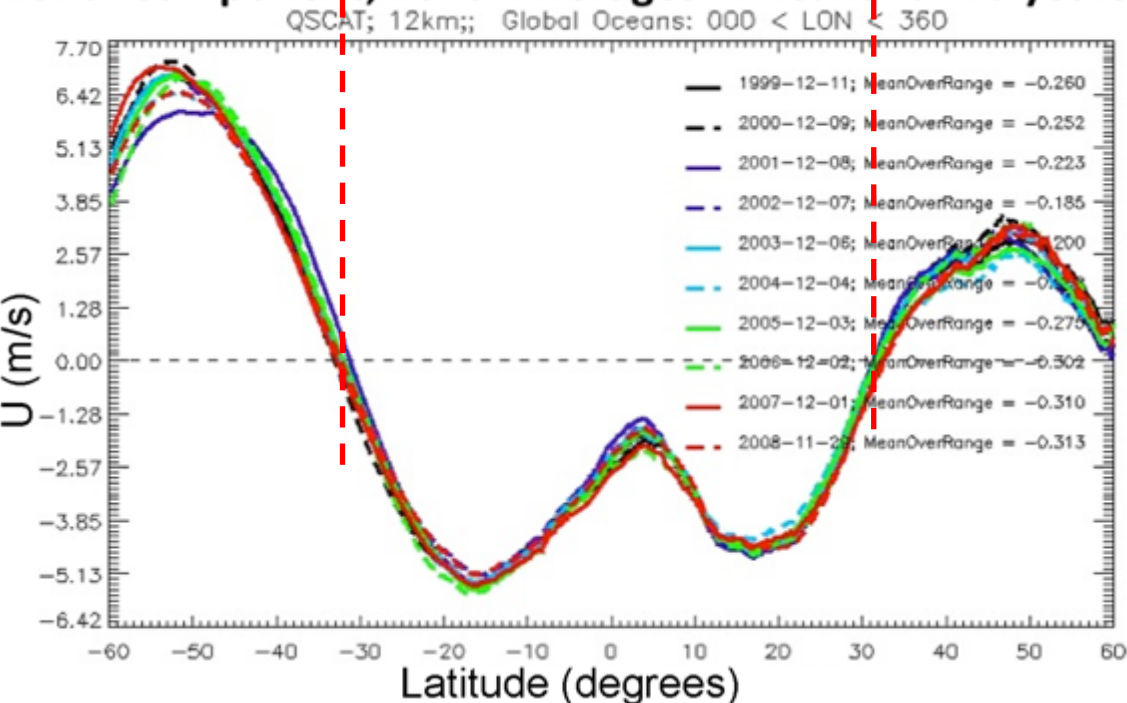
Weather question:

Forecasting
(& analysis)
of tropical
systems?

Zonal Component - 10 year mean
 Year: YEAR99; Resolution=12km; BeginDay 1999-10-30; Days 3638; BeginOrbit 01887; _2weeks260;

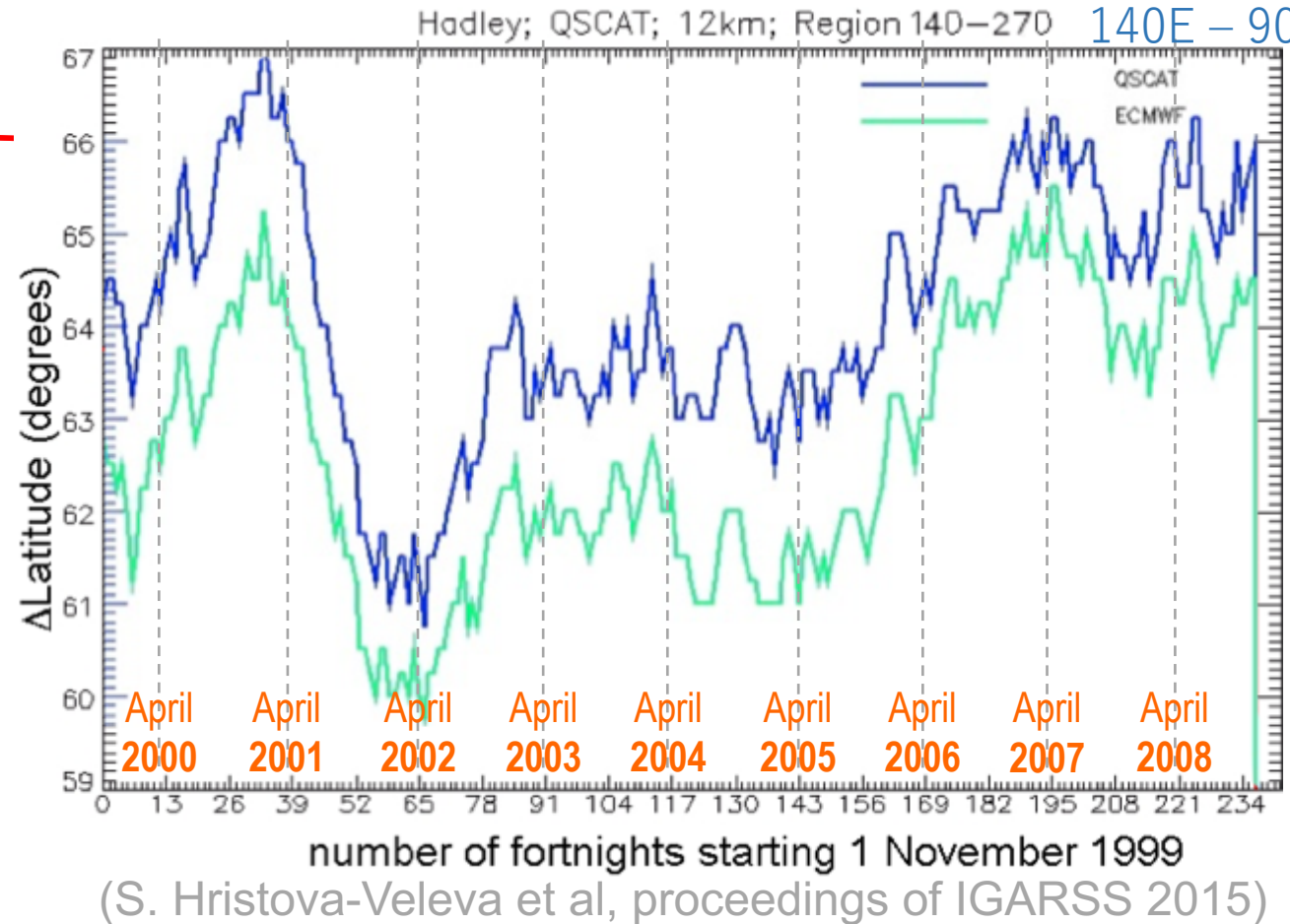


Zonal Component; Zonal Averages – means for 10 years



We have direct observations of the Hadley circulation from ocean-surface wind from scatterometry

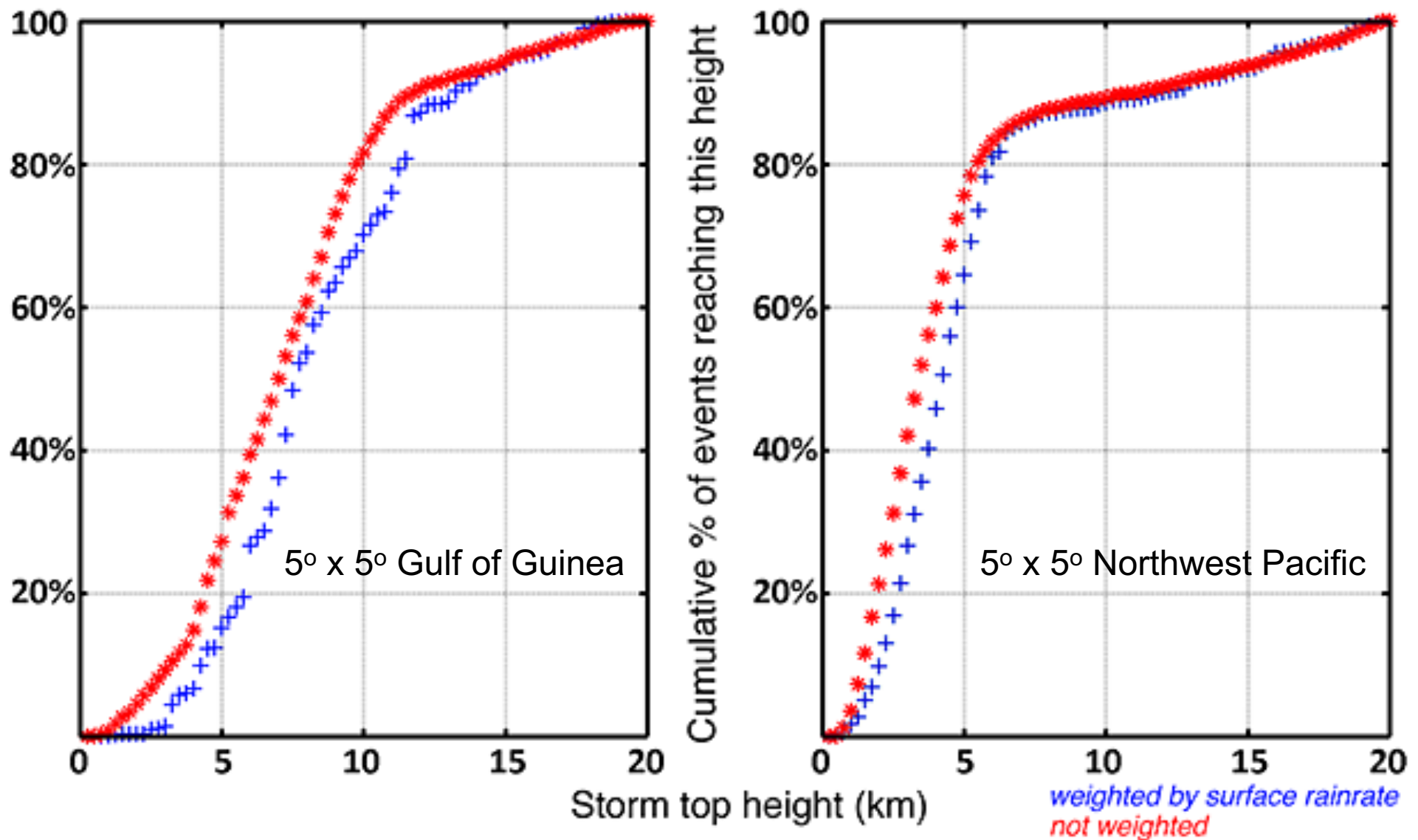
Pacific only
 140E – 90W



So: What about precipitation?

How did/does the precipitation evolve?

Prototypical cumulative distributions of “storm height” from 16 years of TRMM radar data, In the tropics:
and at mid-latitudes:



How did/does the precipitation evolve?

So can these cumulative distributions of storm height be made for each season, e.g. JJA in the Northern hemisphere or DJF in the Southern hemisphere, then tracked from year to year?

Answer: TRMM radar does not collect enough data over a single season to represent an entire *cumulative distribution* that can then be tracked interannually

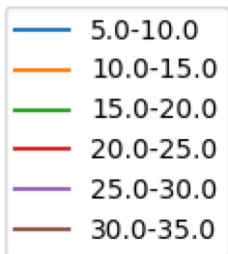
However, we can estimate the first two conditional moments (total number and mean), conditioned on a minimum height threshold, then track those two from 1998

That is what we did, for different latitude bands in different zones, using two conditional thresholds, > 5000 m AMSL or > 8000 m AMSL

North Pacific

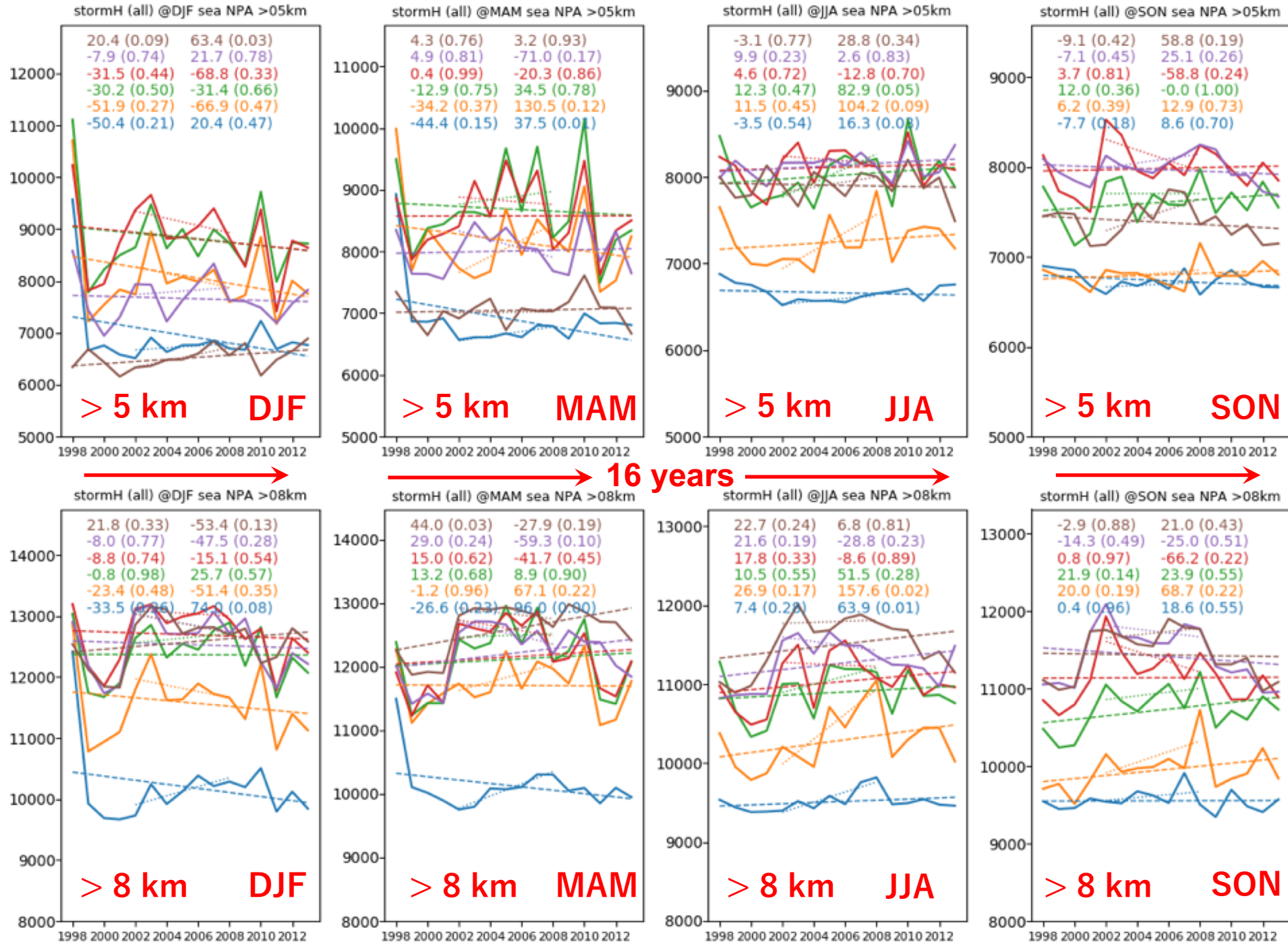


Latitude bands:



Mainly increasing trends during the summer (JJA)

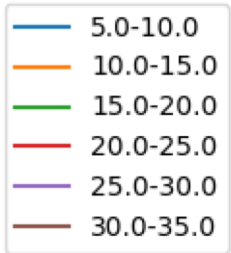
Annual-Average Cloud Top Height



South Pacific - East



Latitude bands:

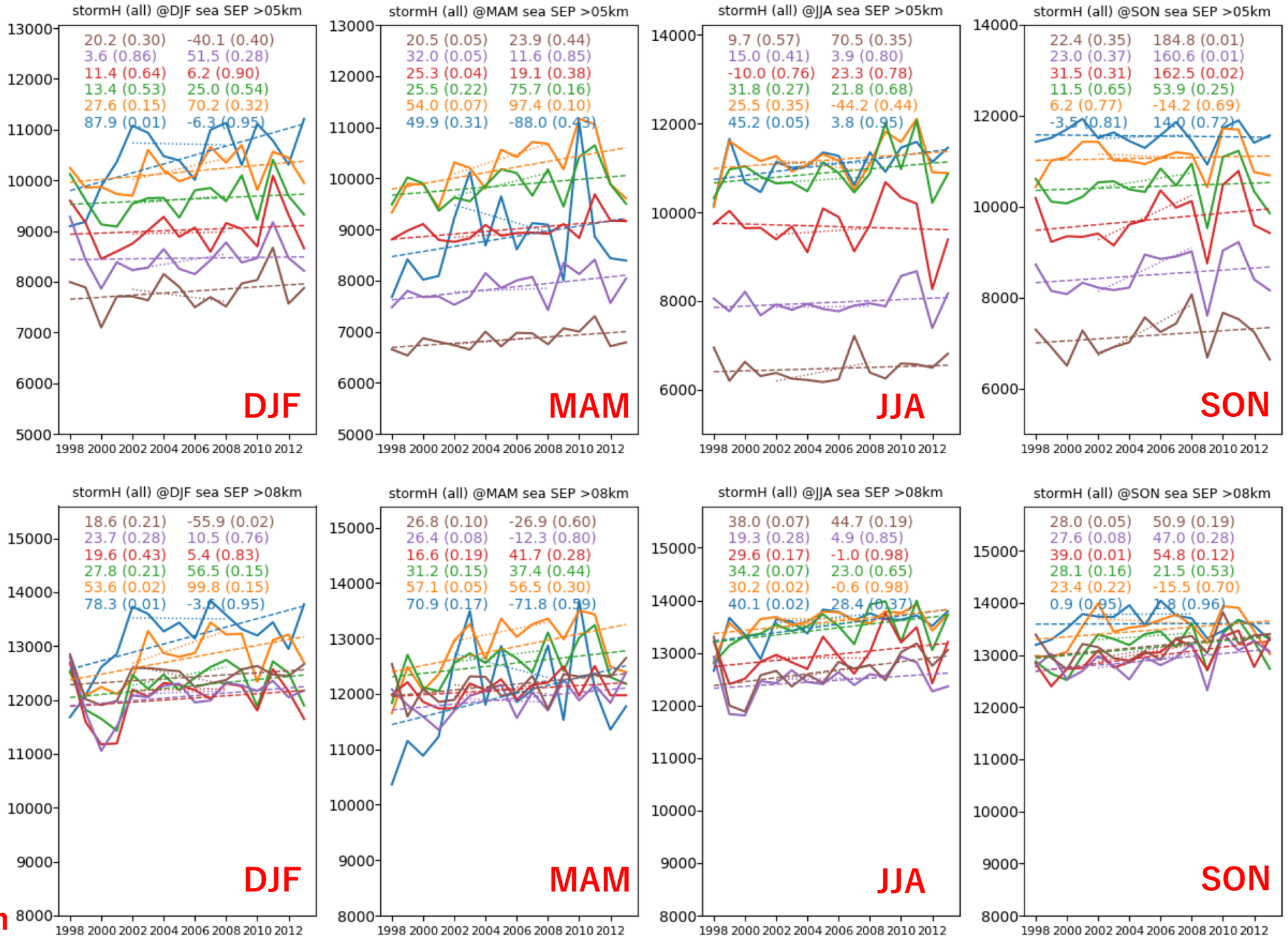


Almost uniformly increasing trends

> 5 km

Annual-Average Cloud Top Height

> 8 km

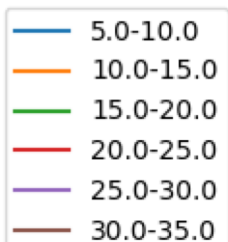


> 5 km

South Pacific - East



Latitude bands:

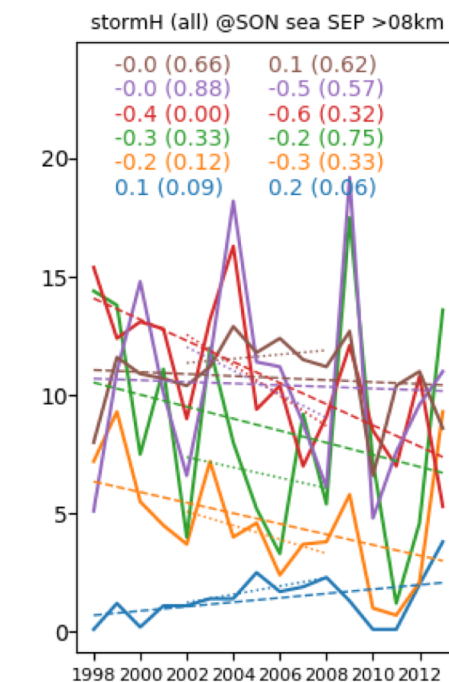
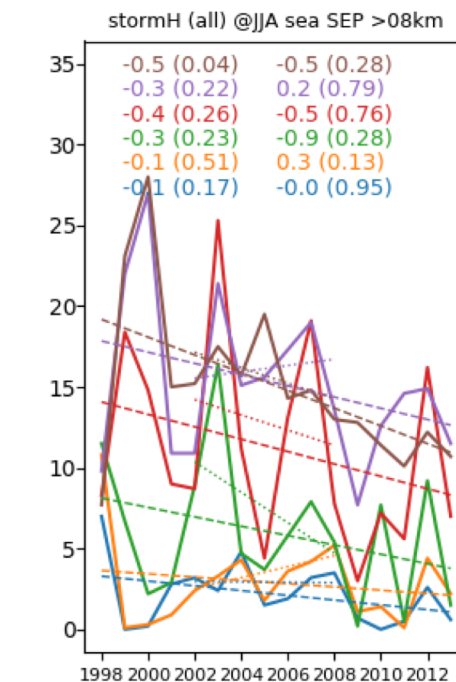
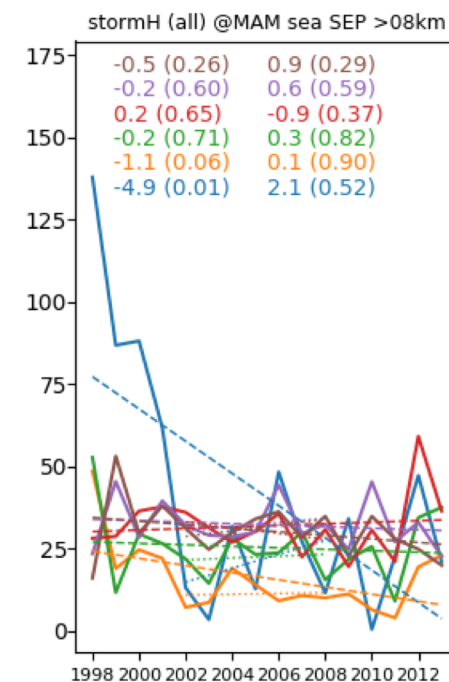
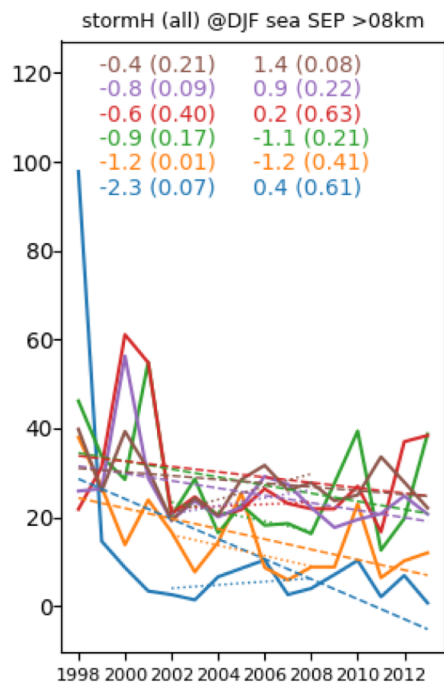
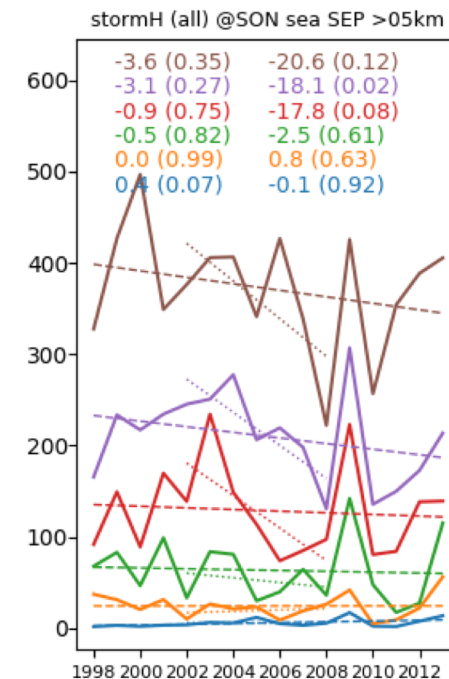
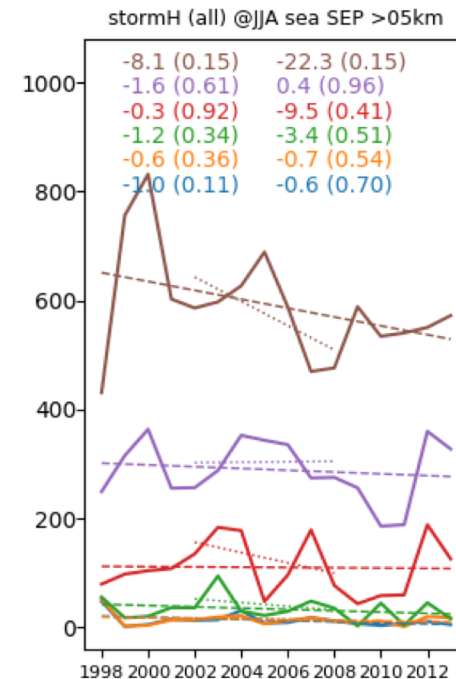
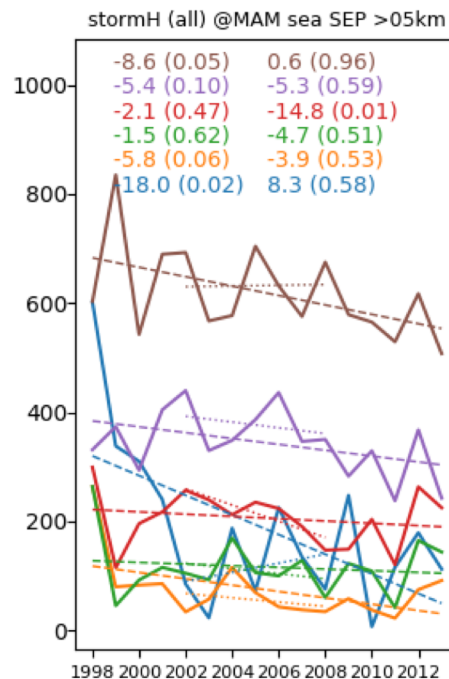
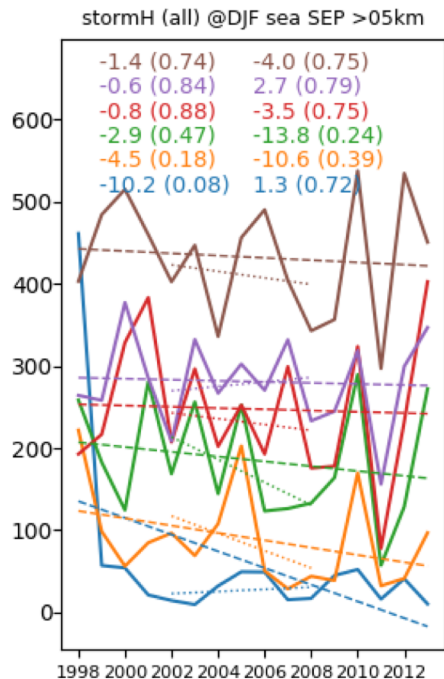


Cloud Top Height – **total count**

Surprise:

*Almost uniformly
decreasing trends
(in the counts)*

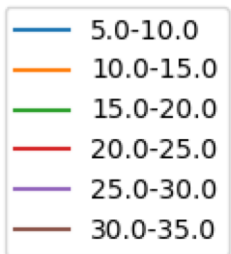
> 8 km



North Pacific



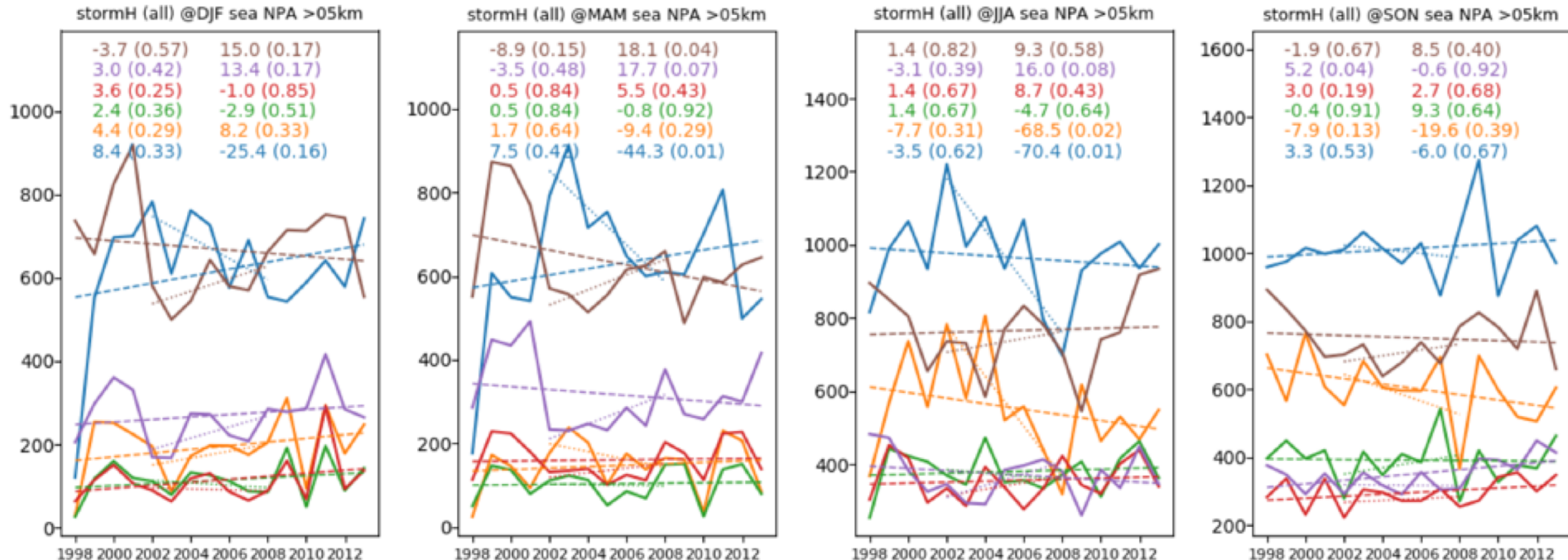
Latitude bands:



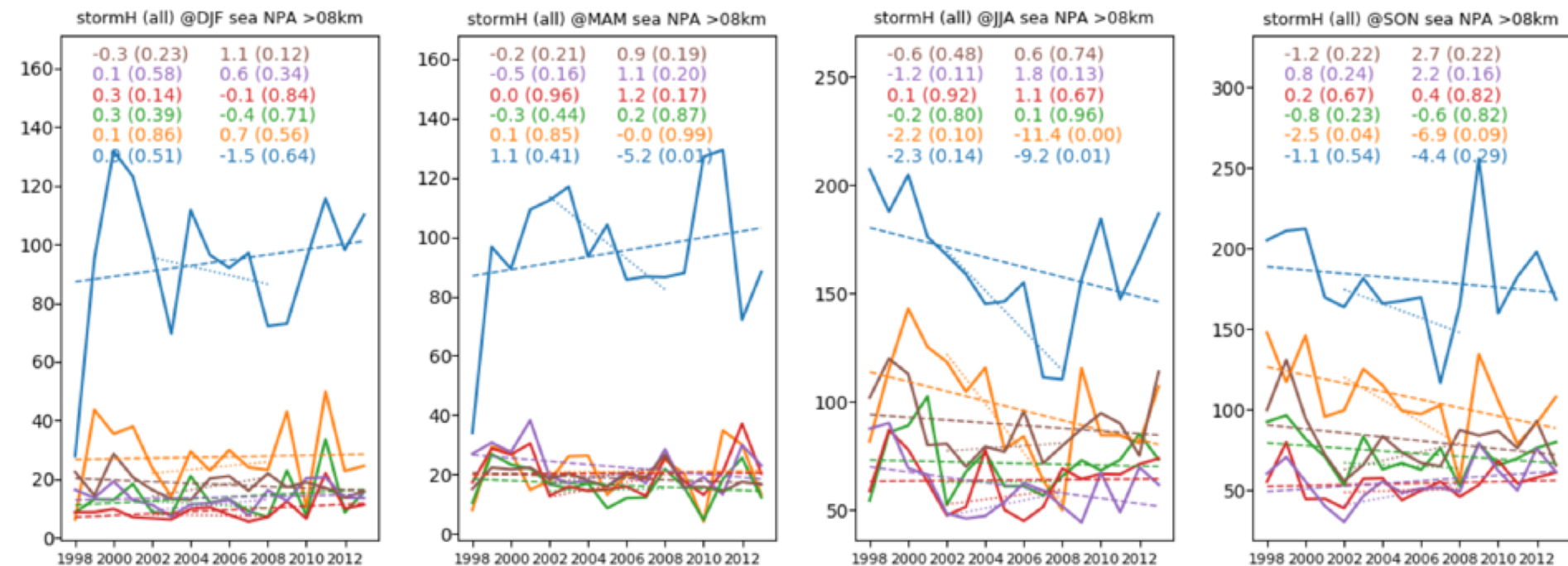
Cloud Top Height – **total count**

Surprise:
Mainly decreasing trends
in the counts
during summer (JJA)

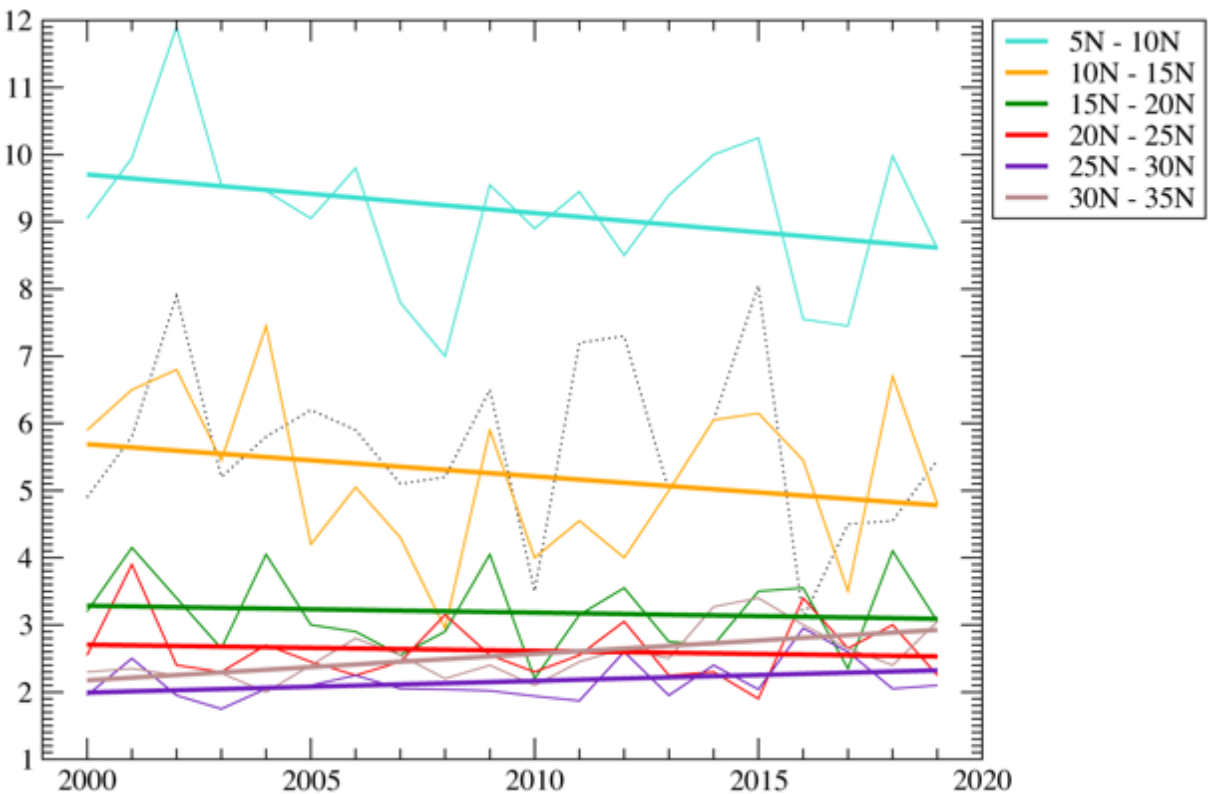
> 5 km



> 8 km

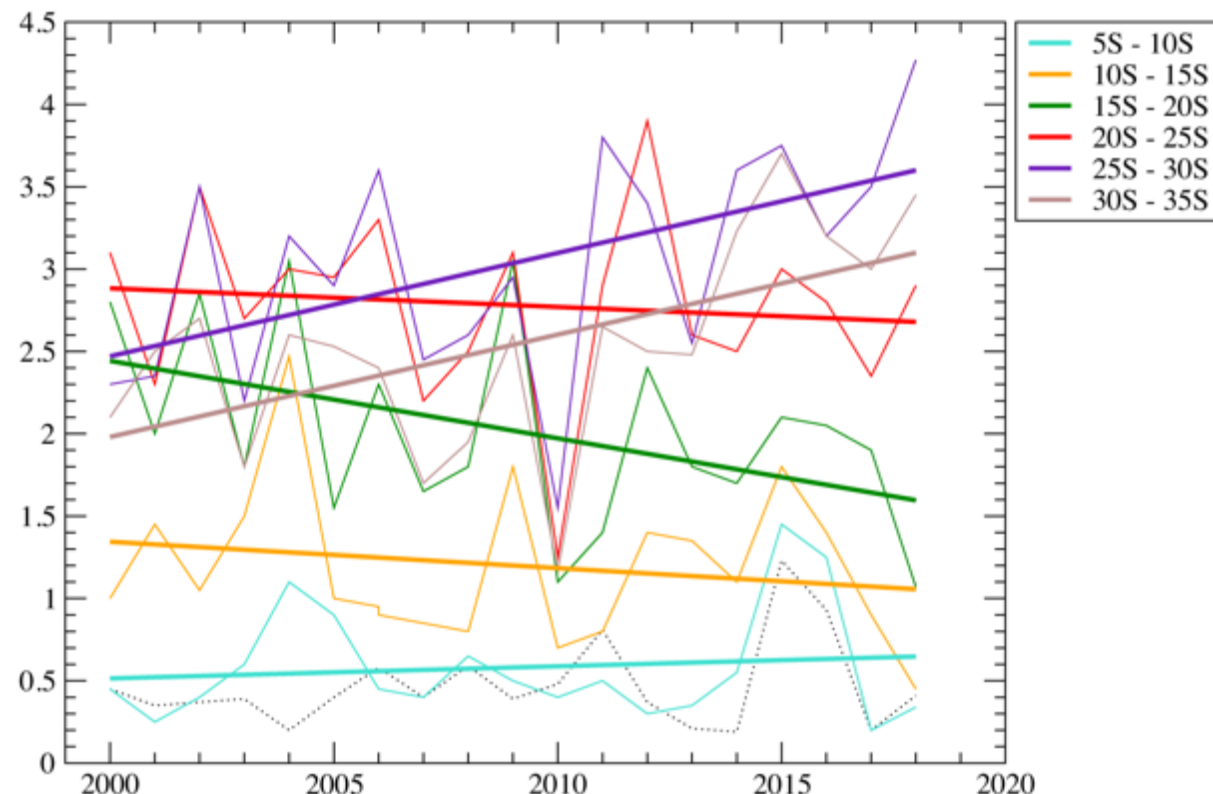


North Pacific



JJA Surface precipitation trend
according to NASA IMERG

South Pacific - East



DJF Surface precipitation trend
according to NASA IMERG

Total number of columns observed **by TRMM radar** every season
in each 5° (lat) x 65° (lon) box is on the order of **100**
(the exact sample size varies between 20 and 400)
which could be from as few as two storms

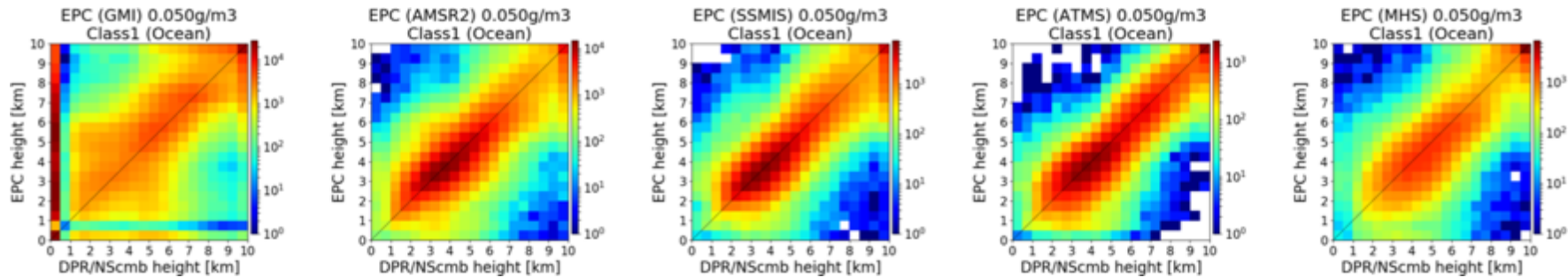
This sample size is too small to infer the probability distribution ...

So: is it possible to use **radiometer** observations?

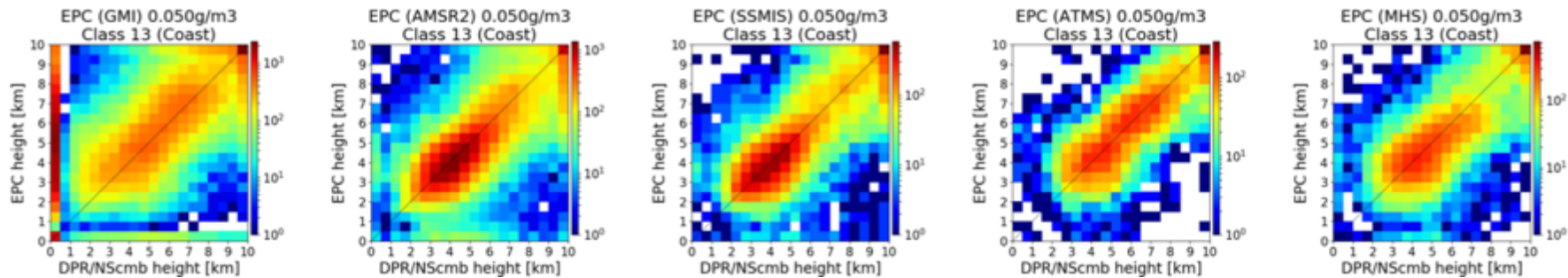
it *IS* possible to use radiometer obs to estimate storm height

Retrieved maximum height with condensed water content $> 0.05 \text{ g/m}^3$ for different radiometers (left to right)
(retrievals on vertical axis, GPM radar truth on horizontal axis)

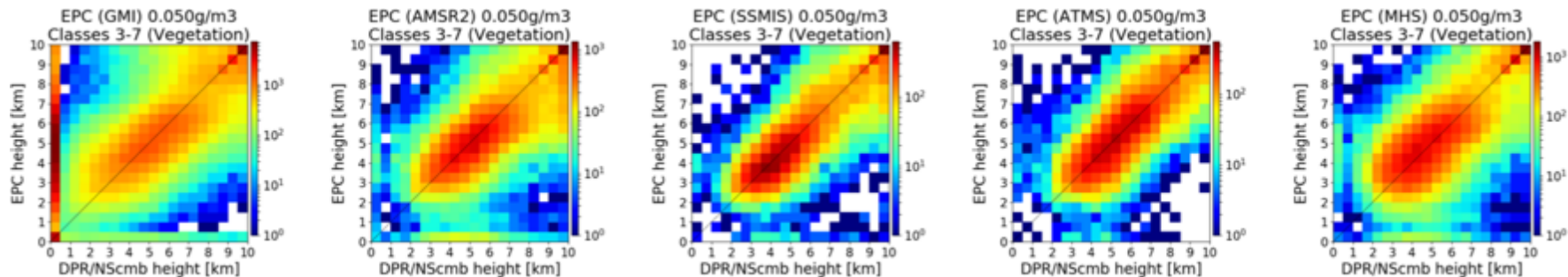
ocean



coast



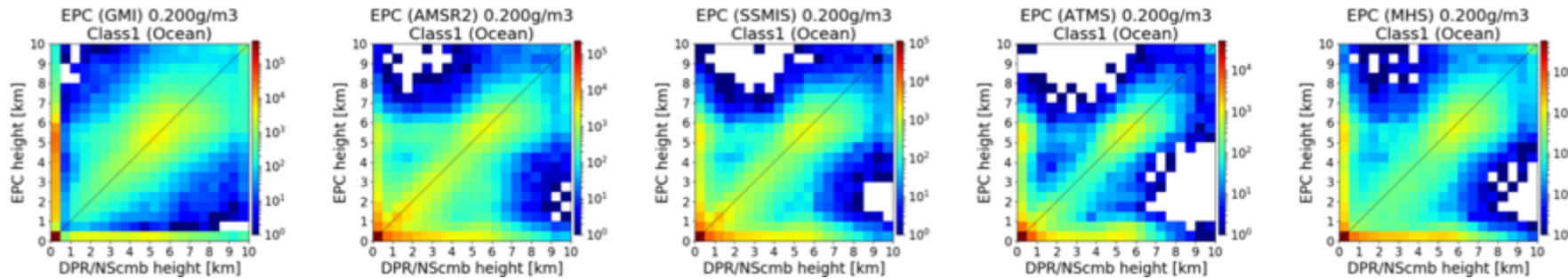
land



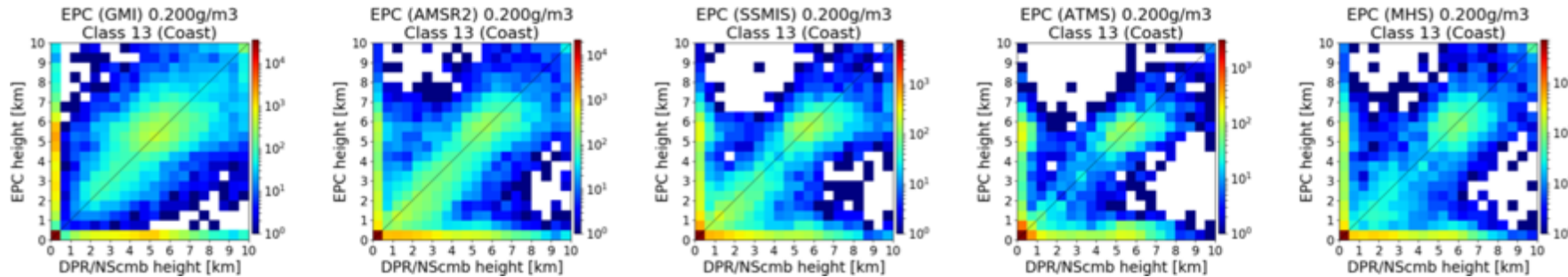
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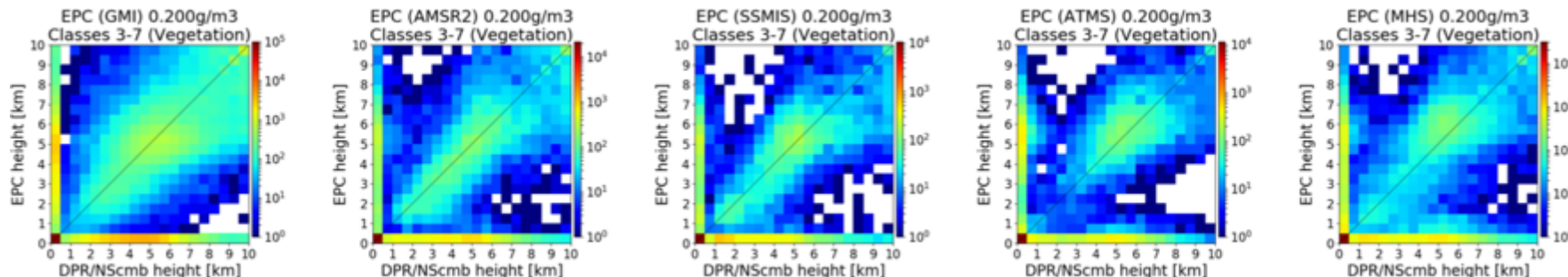
ocean



coast



land



it ***IS*** possible to use radiometer obs to estimate storm height

We can also retrieve depth of condensed water from top of cloud

Compared to the radar, the sampling frequency is multiplied by a factor ~ 50

Estimates have more uncertainty, but as long as they are not more biased ...