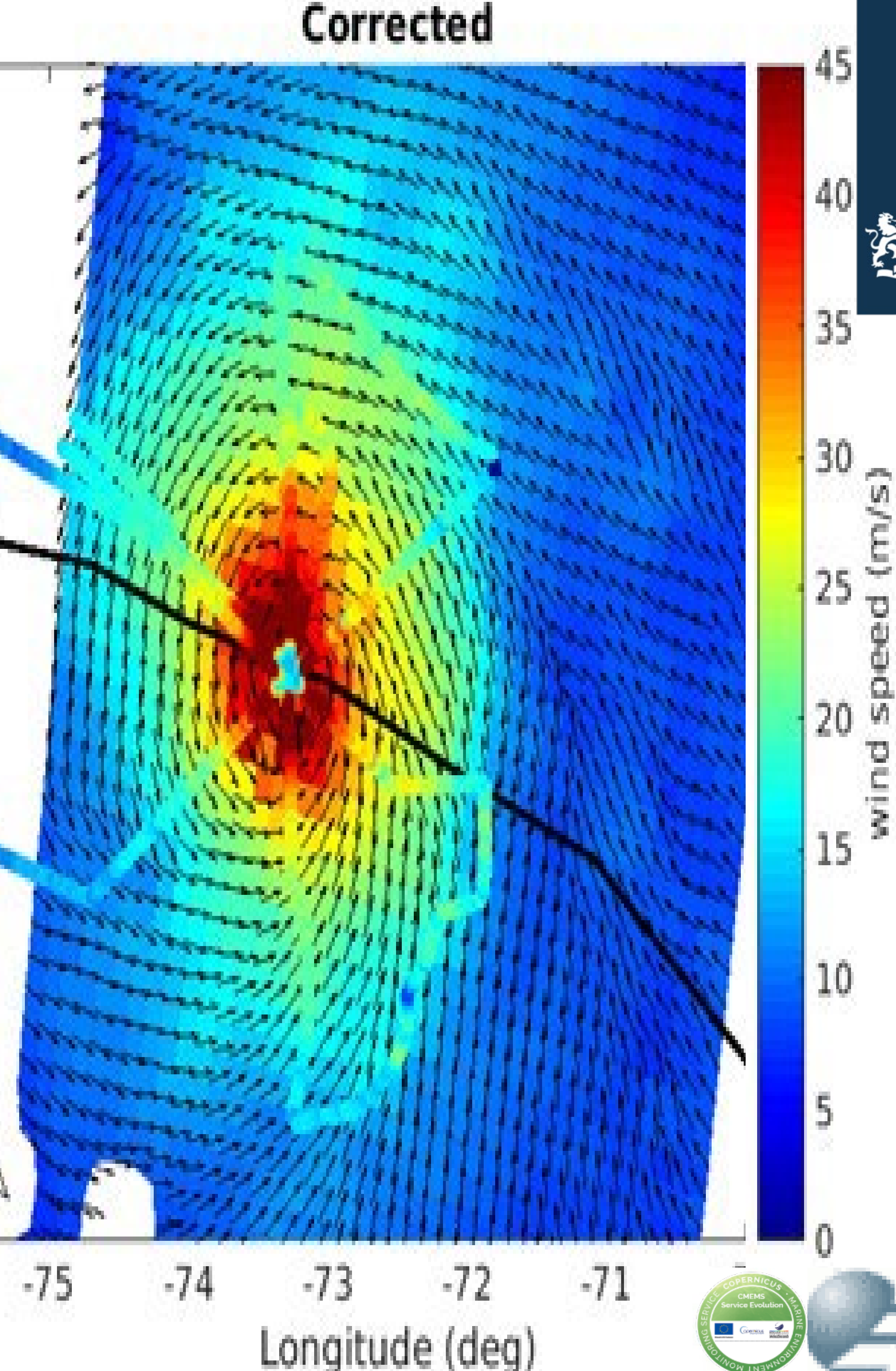

Royal Netherlands
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Hurricane Ocean Wind Speeds

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IFREMER: Alexis Mouche,
JPL: Federica Polverari,
ICM: Marcos Portabella,
NUIST: Wenming Lin,
NOAA: Joe Sapp, Paul Chang, Zorana Jelenak

IWW15, 12-16 April 2021

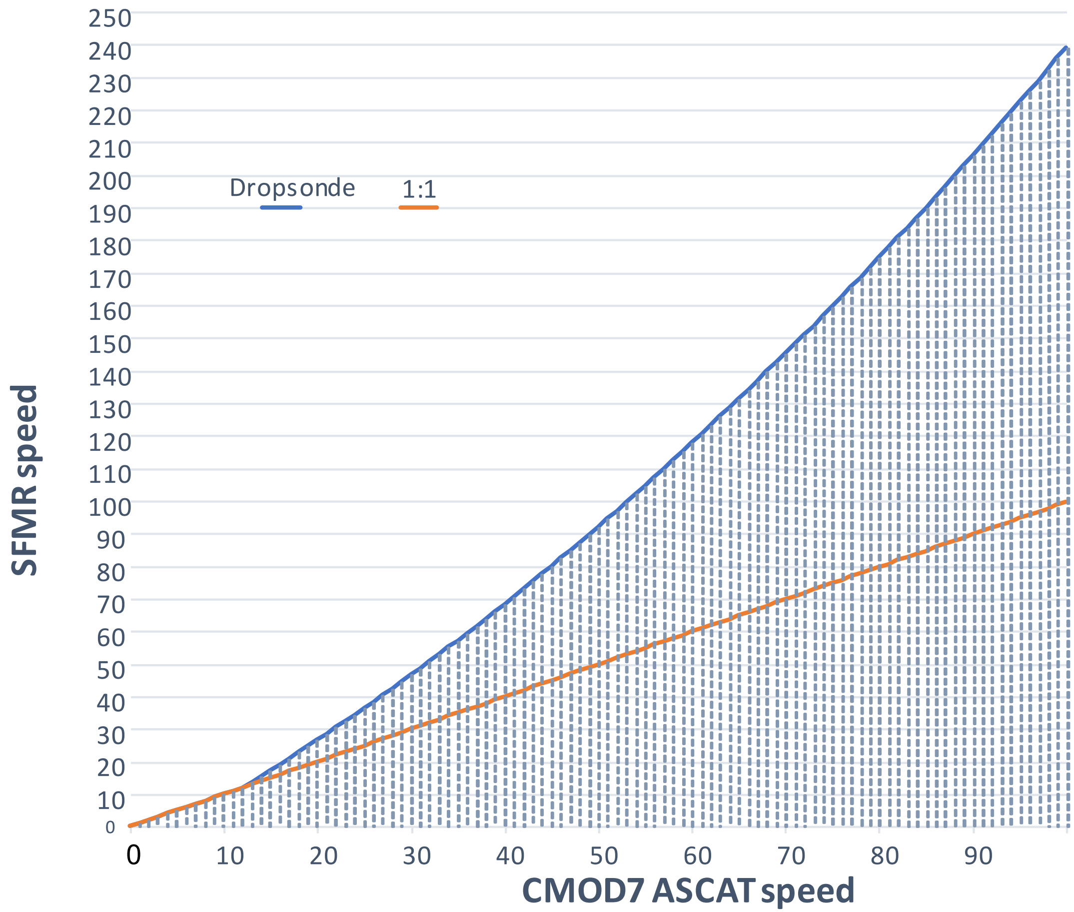
Need for accurate extreme winds

- **Nowcasting**, though **dropsondes** are the adopted wind speed reference here; if the wind speed reference changes, hurricane scales change too as everything relies on dropsonde wind speed calibration (SFMR, Dvorak, ..)
- **NWP**, to formulate **drag** and air-sea interaction stresses
- **Oceanography**, to determine **mixing depth** in hurricanes
- **Climate** monitoring, to determine climate **change** at the extremes
- **Climate** prediction, to well describe coupled ocean and atmosphere dynamics
- Improved description of hurricane **dynamics**

- Satellite ocean surface wind speed calibration for active and passive microwave remote sensing

Validation metrics

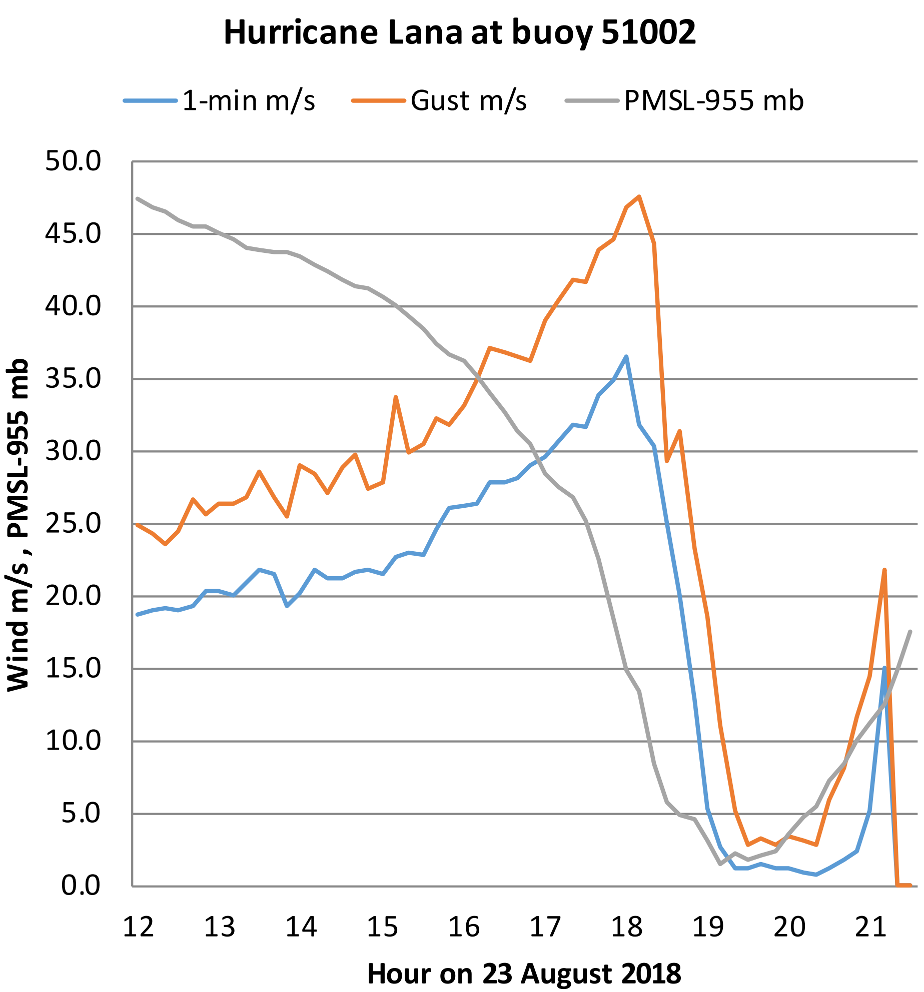
- Based on dropsondes as these are used in the operational community (though open questions remain on their accuracy as articulated in CHEFS)
- Use CHEFS method for spatial scaling, collocation, ..
- SFMR, Dvorak, SMAP, SMOS, .. , depend on dropsondes
- Use stress-equivalent 10-m ECMWF and buoy winds
- Triple collocation
- **CMOD7D**



Polverari et al., in review

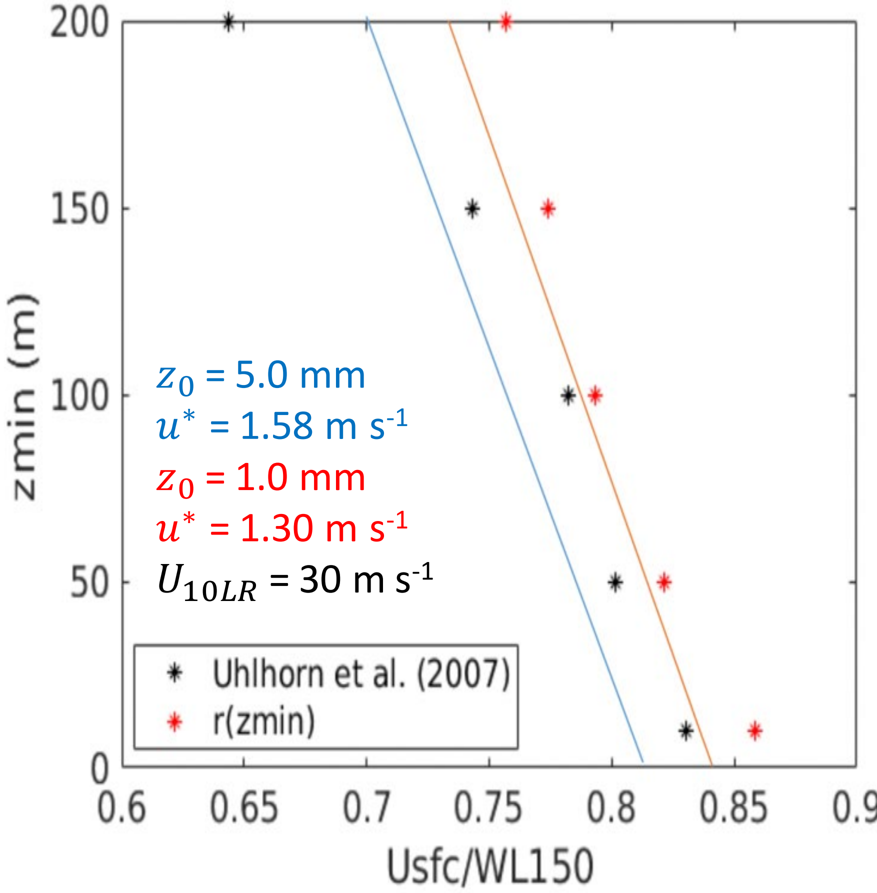
Moored buoys

- Best controlled resource for in-situ wind speed calibration at moderate and high winds
- Work well up to 25 m/s as verified with wind tower
- Dynamically corrected platform winds
- Claims of ocean wave shielding lead to non-substantiated sources
- Cup anemometer biases at extreme winds may be a few % (only)
- Rare encounter with hurricanes
- Ethan Wright, IOVWST 2021



Dropsondes open issues

- Dropsondes cannot follow the wind near the surface, due to the strong deceleration as function of the drag;
- The correction for this leads to an integration effect in the vertical, where the wind profile is logarithmic;
- 10-m SFMR winds in hurricanes are inconsistent with a log profile;
- The position computation by the dropsonde GPS chip has not (yet) been investigated, nor its derivation of speed and acceleration, with may cause further bias in strong deceleration (drag);
- Most passive satellite winds, SFMR, best track, etc. are all calibrated with respect to dropsondes and show the same inconsistency with respect to the buoy winds;
- The above conversion takes the spatio-temporal scale of the verification sources into account, hence differences are believed not to be dominated by local gradient effects;
- On the other hand, ASCAT and ECMWF follow the moored buoy scale (up to recently).
- Buoy winds are not frequent in hurricanes, but are validated by masts to be unbiased up to 25 m/s (within ~10%), while at 25 m/s the conversion bias from (1) is **45%**;
- Other in-situ (incl. land-based) wind sources suffer from wind flow distortion biases, positive and negative, or from height down conversion errors to 10m;
- These results call for further investigation of the true in-situ wind speed reference in hurricane conditions.
- Due to the above-mentioned inconsistency, calibration of satellite winds (above 25 m/s) is uncertain, as well as their assimilation in NWP and the associated drag formulation in Earth System Models.



3. Hurricane Eyewall Detection

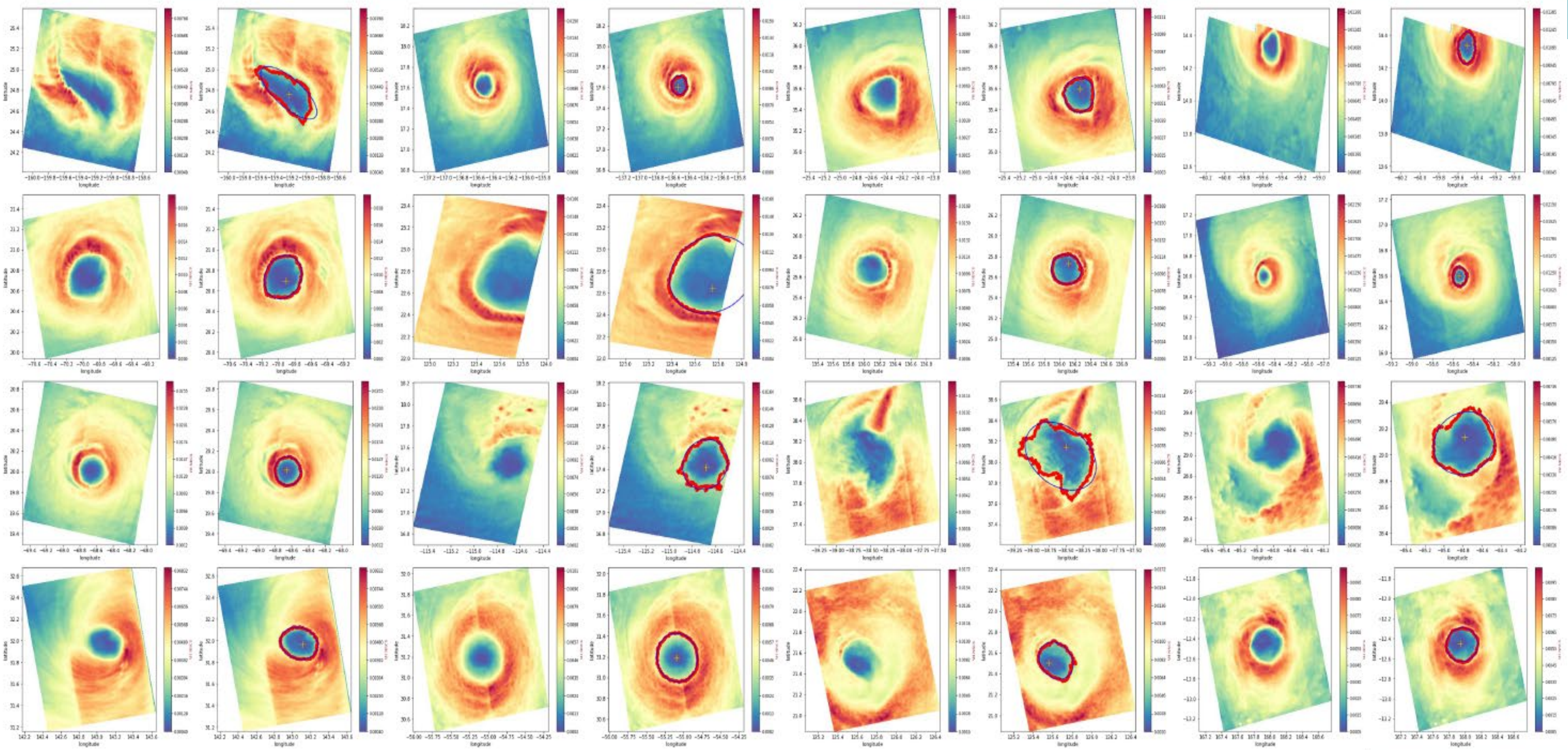
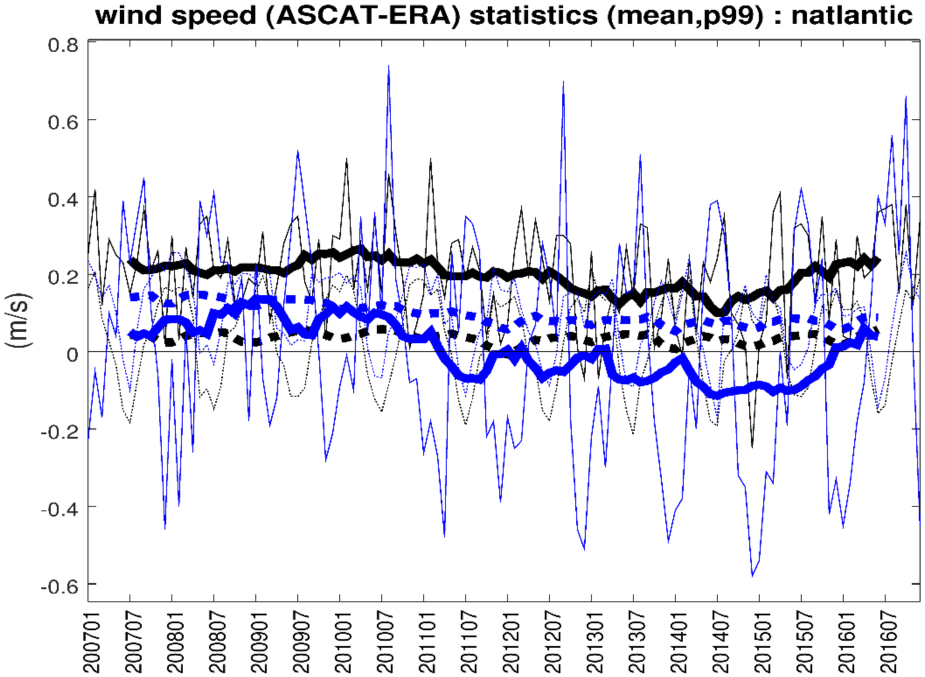
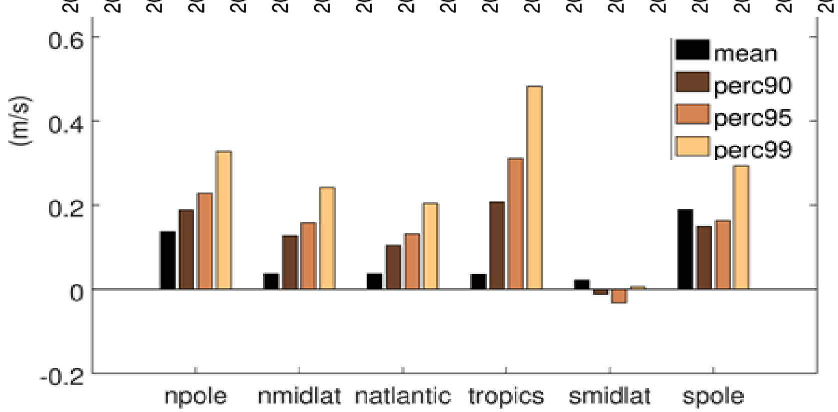


Figure 10. Hurricane Eyewall Detection Results

- Exploit SAR for hi-res information
- 2DVAR for vortex construction for SAR and scatterometer

Decadal differences ASCAT-ERA5





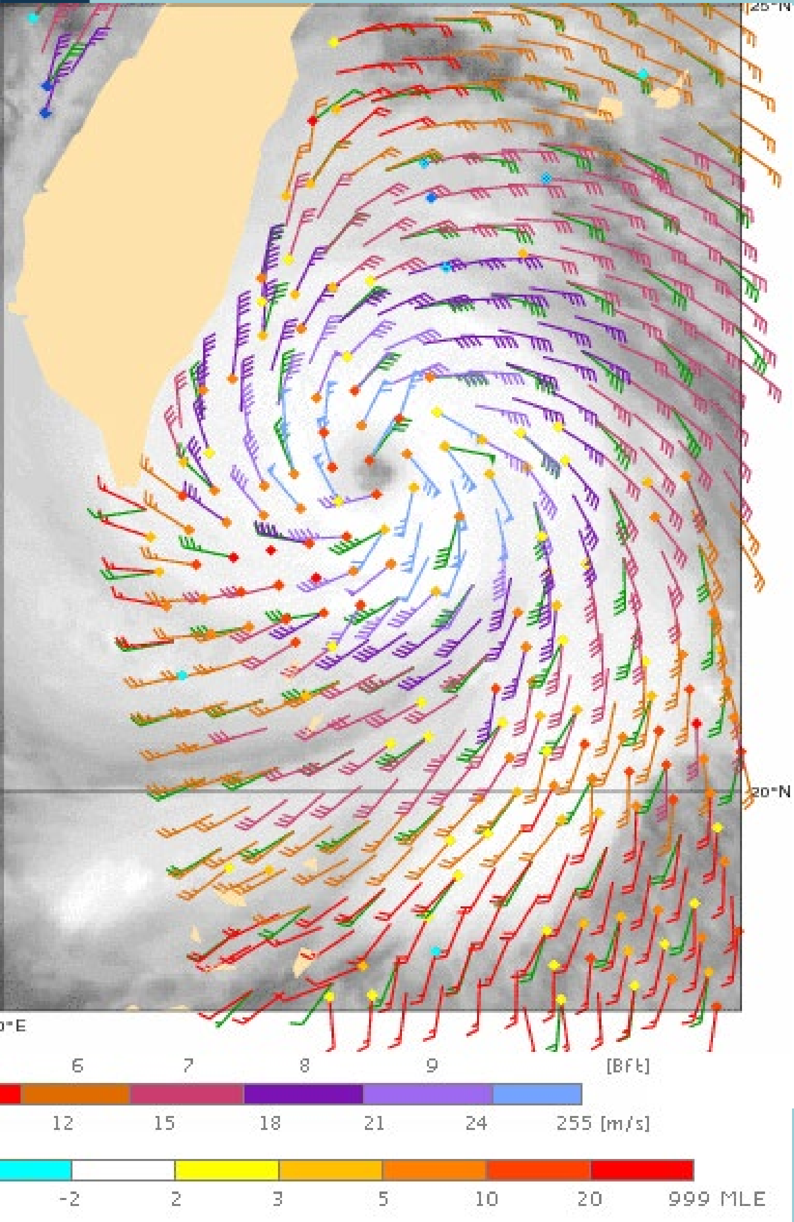
- Windstorm Information Service
- C3S WISC
- ASCAT versus ERA5 first guess
- Also ERS, QuikScat and OSCAT
- Passive wind instruments reliable? From 1988

Discussion

- Hurricanes are among the deadliest and costly natural disasters
- Extreme wind measurements come in two different flavours
- Uncertainty about the extremes propagates into the modelling of hurricane dynamics and hurricane occurrence
- Further research is needed on dropsondes wind speeds, particularly in the lowest tens of meters
- Although moored buoy winds show less dispersion around 20 m/s than dropsondes, there is room for further uncertainty assessment and attribution (Wright et al., IOVWST 2021)
- Mixing instruments/producers for determining climate trends is not recommendable due to variable sampling and calibration
- Validate reanalyses by collocated stable single-instrument series
- ESA MAXSS project on satellite hurricane winds

- Further supporting slides follow this slide

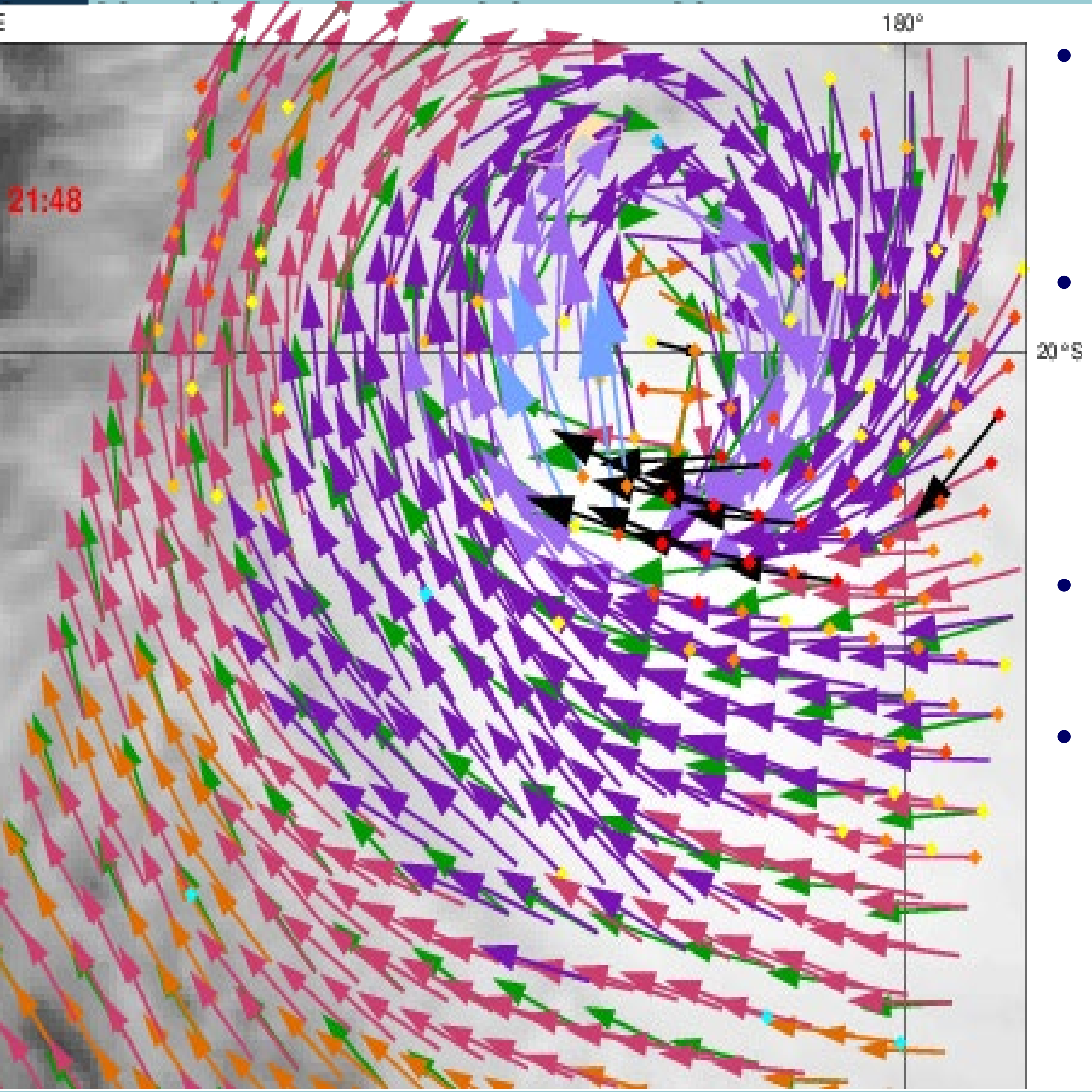
EUMETSAT CHEFS Objectives



- **VH GMF**: The understanding of the future C-band VH information contribution to high and extreme wind retrievals from C-band scatterometer missions;
- **Spatial scaling** of extremes: The definition of spatial scaling issues and related consequences for product sample resolutions and validation approaches;
- **Understanding** of extremes: To further understanding of satellite remote sensing of high and extreme wind conditions over the ocean.

- In-situ wind speed reference needed for all extreme wind products, from satellites, reanalyses to NWP models

CHEFS



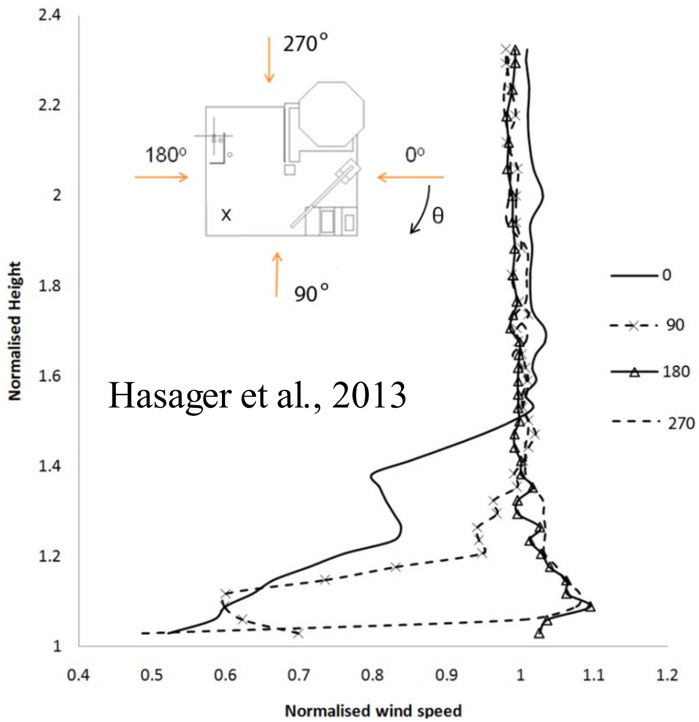
- EUMETSAT ITT 16/166
  - Extreme winds calibration
  - VH test data
- KNMI
  - EPS-SG design and VH
  - GMF and retrieval
  - Calibration strategy
- ICM
  - Scatterometer science
- IFREMER
  - SAR wind retrieval
  - Data lab, L-band, GMF

Other references?

- +ve and –ve wind flow distortion around platforms
- Verification shows differences to platforms 2x as high as to buoys; what is this scatter? Does it cause bias? Useful as calibration reference?

- Platform motion (ships)

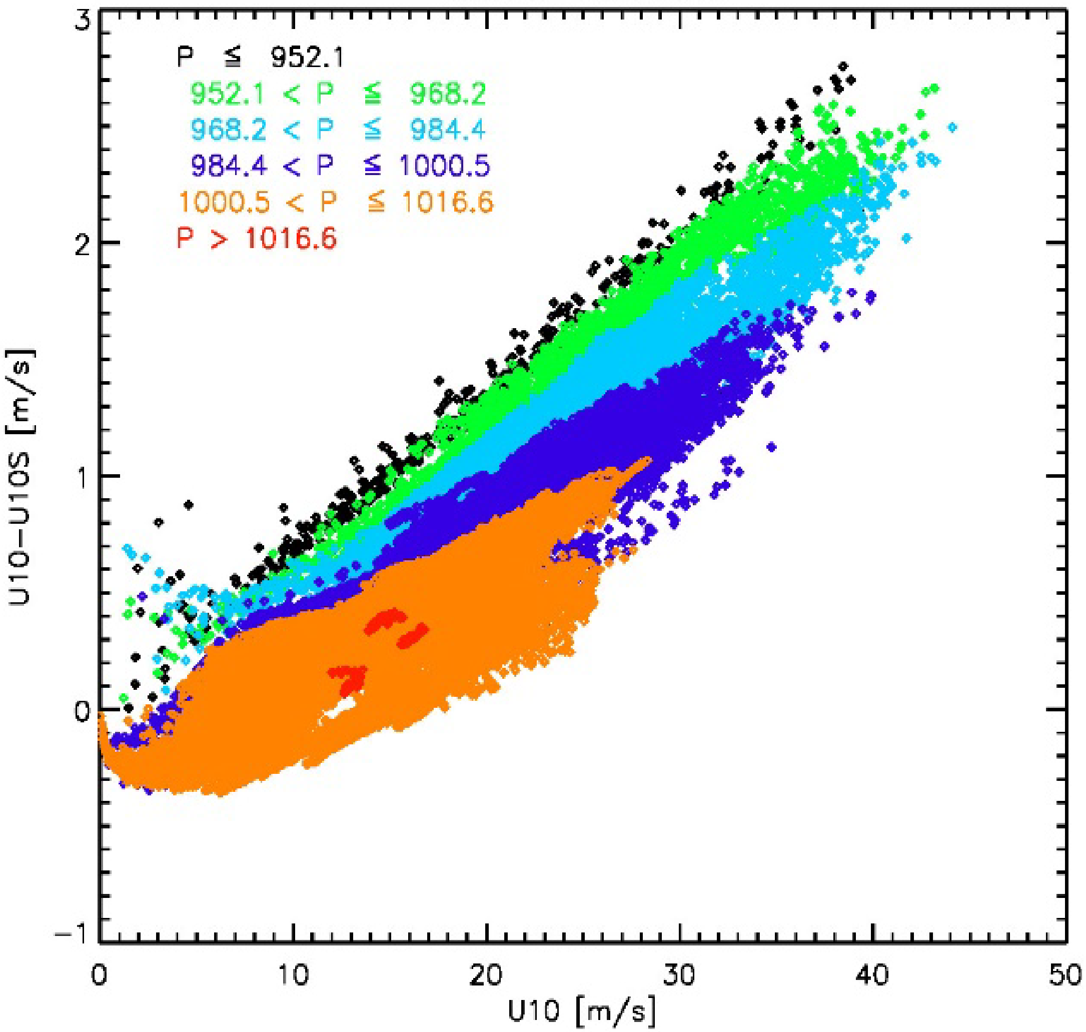
- Errors are not well controlled, larger than for moored buoys and tend to be environmentally dependent



Stress-equivalent winds in TCs

- Only near tropical cyclones (TC)
- Pressure and humidity affect air mass density
- Particularly near TC centres
- At extreme winds up to a few m/s (5%)

➢ Needs to be accounted for

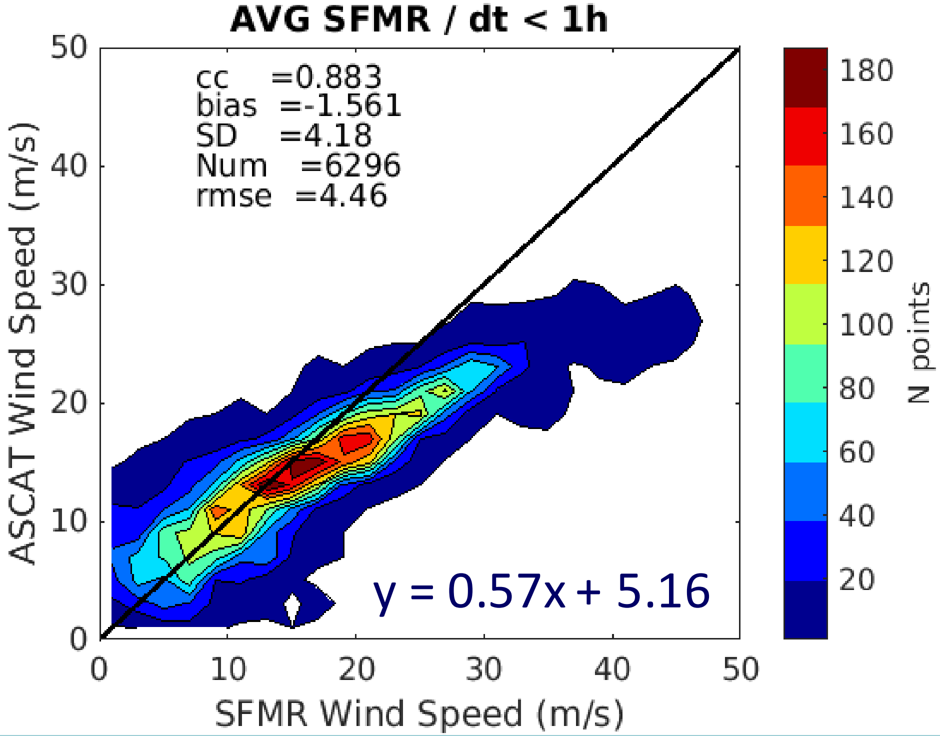


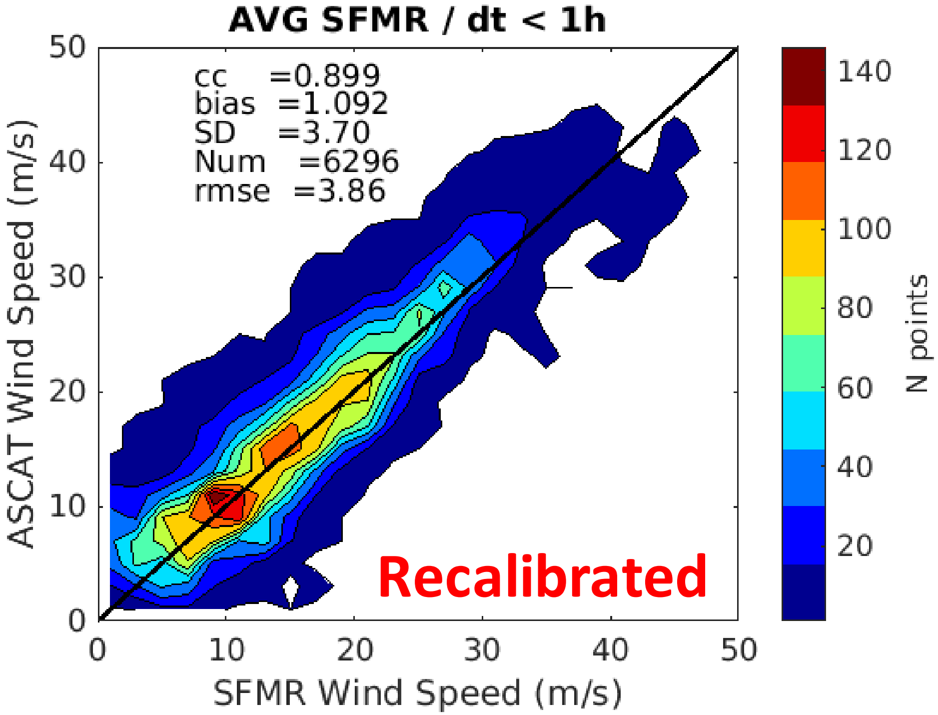
ASCAT-VV calibrated to SFMR

- Storm centered
- SFMR relatively high
- SFMR is based on dropsondes
- ASCAT VV is based on buoys

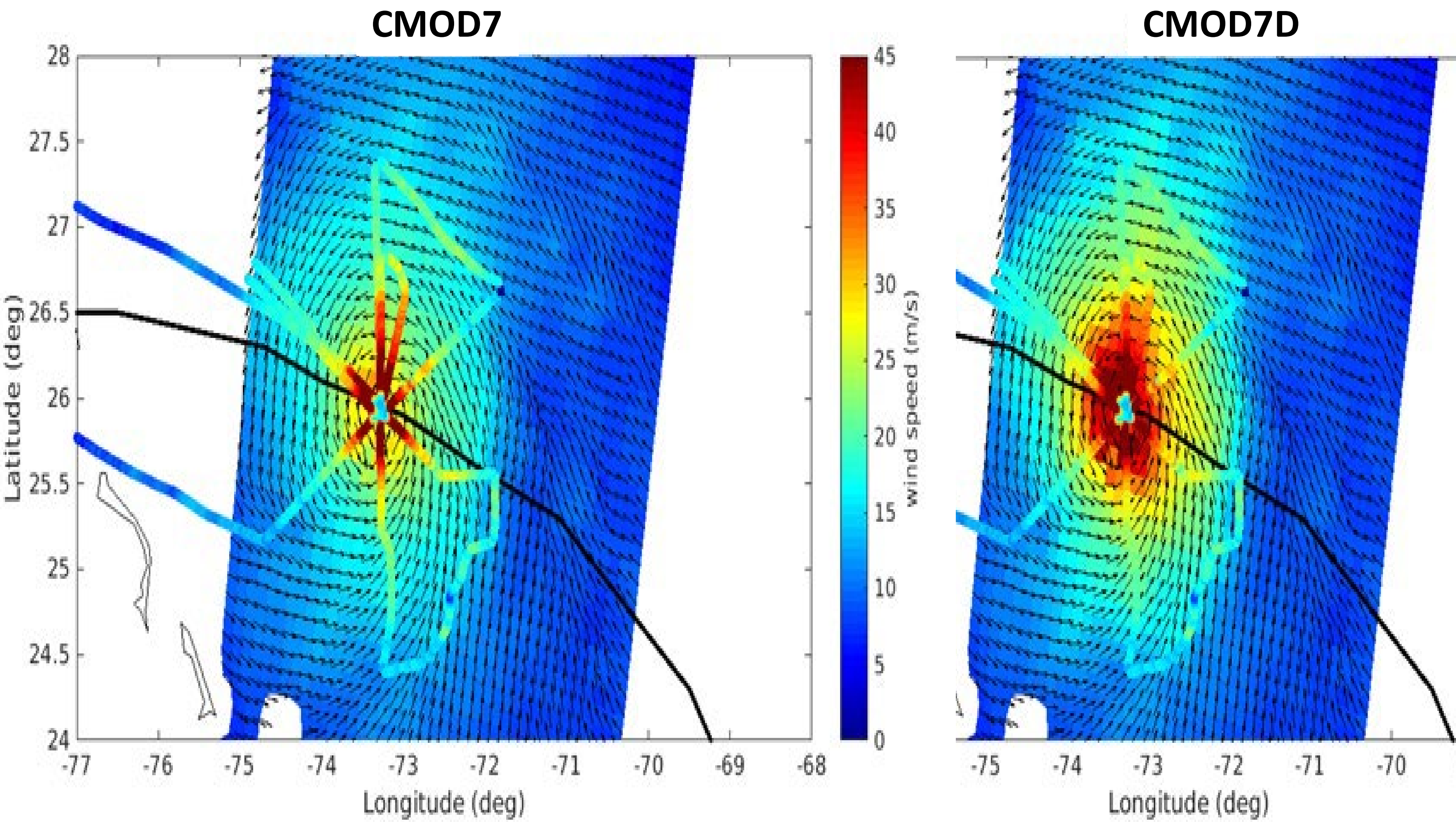
- > 12 m/s apply for x=V(ASCAT): V'(ASCAT)=0.0095x^2+1.52x-7.6
- Better cc, bias, SD and rmse for the same sample with CMOD7D

✓ Good match up to 40 m/s

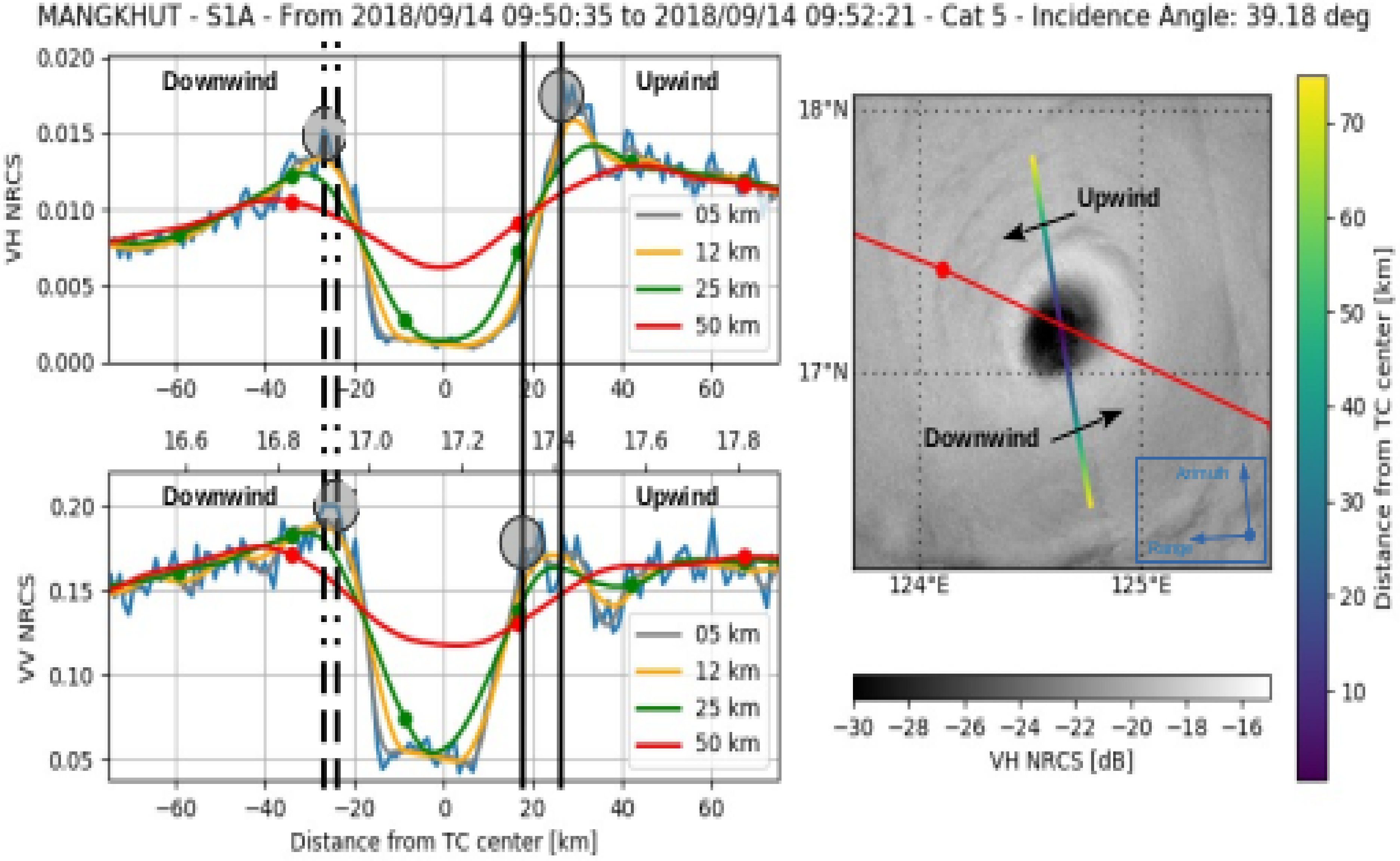




Operational CMOD7 versus CMOD7D

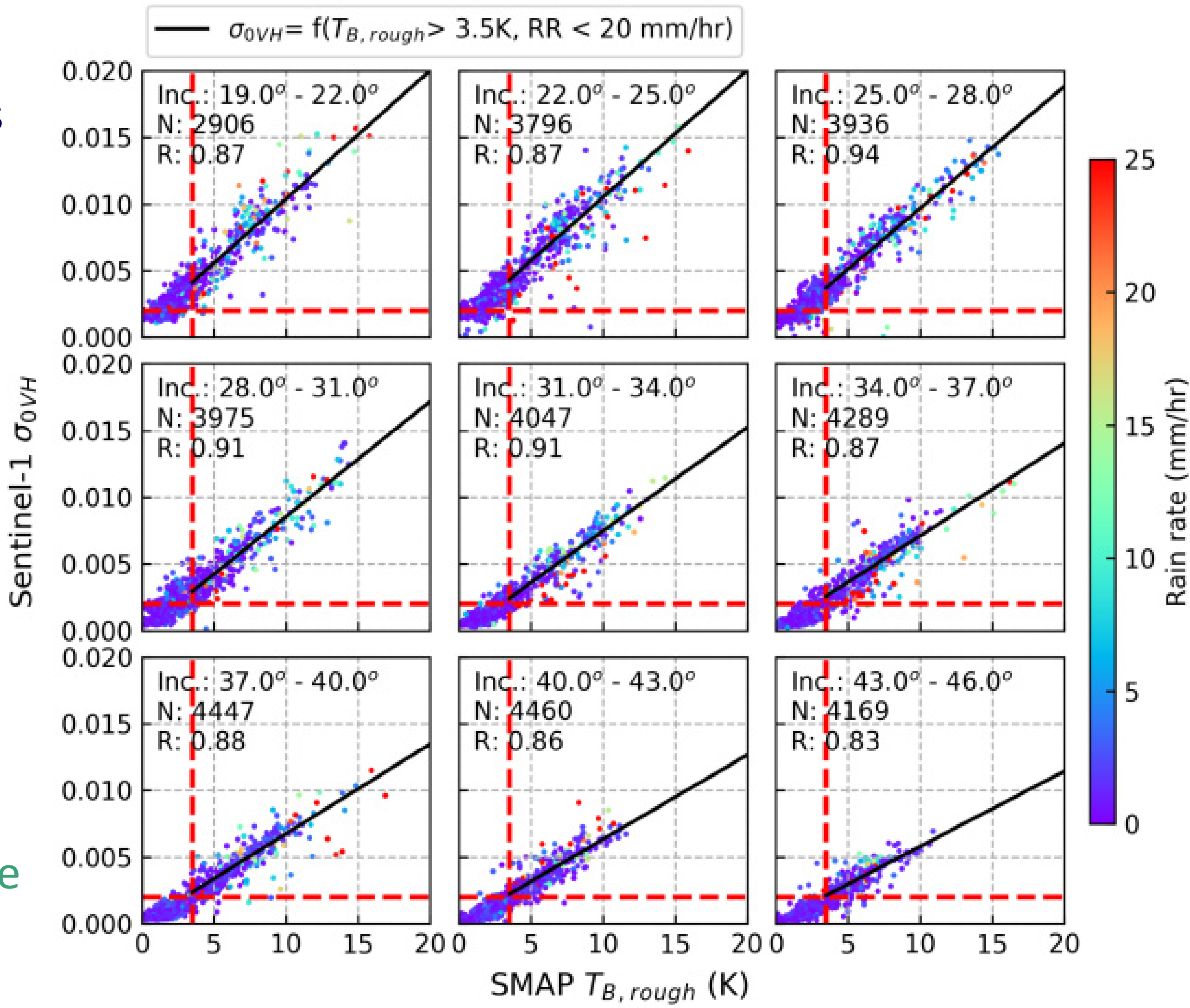


SAR aggregated NRCS



VH and L-band T_B

- Linear dependency
- Theoretically not obvious to relate Bragg to L T_B
- Measurement accuracy will determine quality of L-band and VH extreme winds
- High rain enhances VH NRCS at 19-22 and 40-43 degrees
- High rain reduces VH NRCS at 22-25 and 31-34 degrees
- SCA VH is excellent choice for extremes

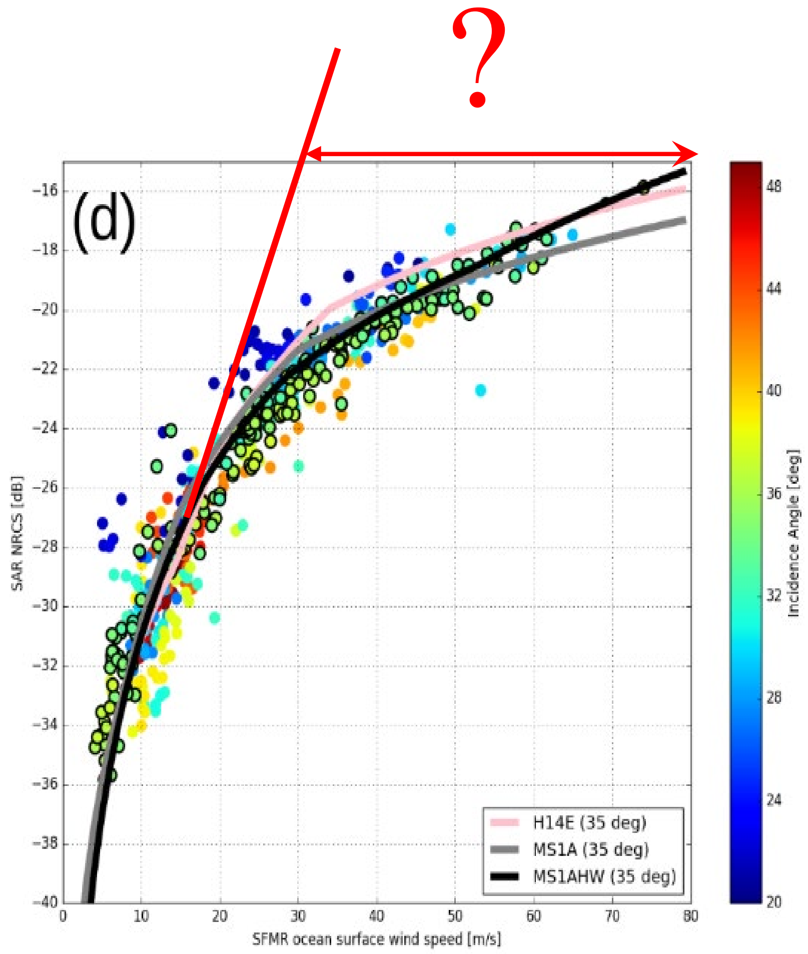


Recommendations

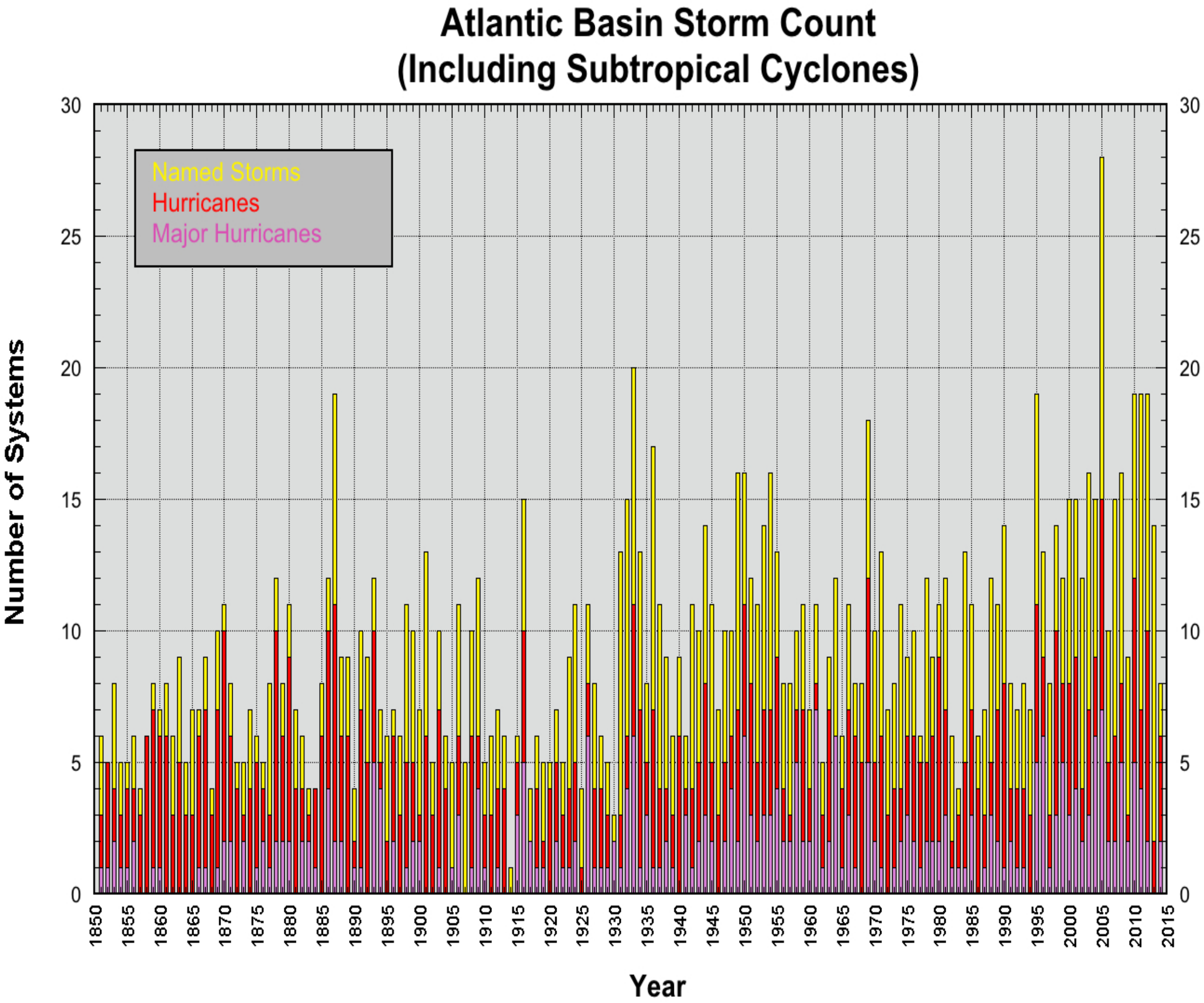
- Use dropsonde U_{10S} rather than WL150
- Perform a log-profile analysis
- Investigate speed-dependent deceleration error dropsondes at 10 m
- Convert buoys, dropsondes and model winds to U_{10S}
- Investigate different buoy types and possible wave effects on buoy measurements
- Investigate direct buoy-dropsonde collocations > 15 m/s
- After in-situ wind speed calibration, SFMR needs adaptation, as well as all satellite sea surface winds
- It furthermore will allow NWP model drag parameterization tuning
- Closer collaboration with JCOMM, satellite wind producers and ECMWF will be very beneficial to consolidate the in situ, satellite winds and NWP community practices
- Refine ASCAT calibration, VV GMF (cone) and retrieval at high/extreme winds
- Extend SAR and NOAA campaigns for refined geophysical studies

CHEFS Conclusions

- We still lack a consolidated in-situ wind speed reference
- Affects satellite & NWP products and hurricane advisories!
- Confidence in moored buoys up to 25 m/s
- U10S needed
- Questions drop sondes?
- ASCAT VV correlates well at high winds
- SCA VH excellent choice

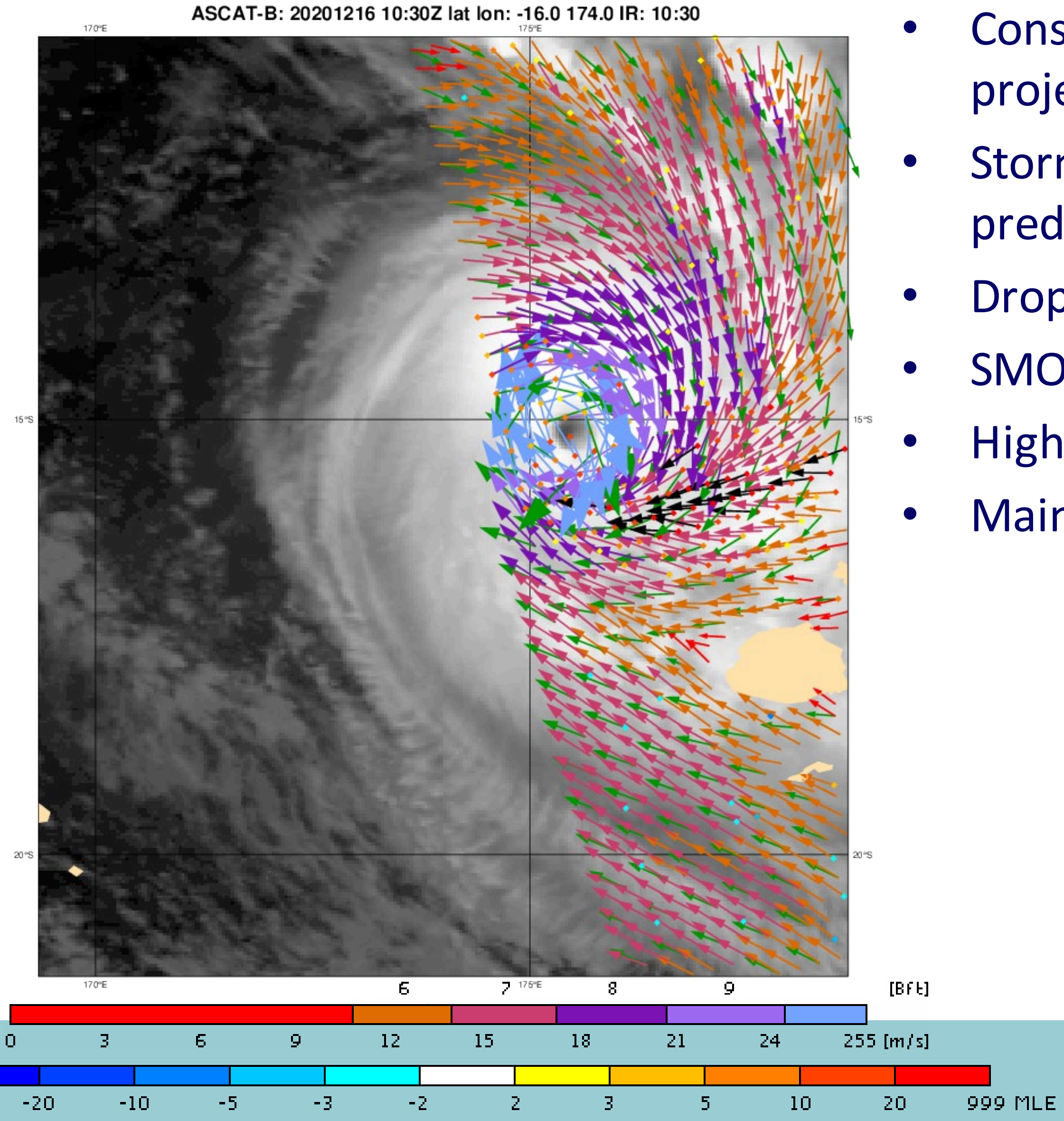


Decadal extreme changes



- Huge year-to-year variability in extremes
- Depends on El Nino
- ➢ Use longest possible satellite record
- Depends on observing system sampling, single processor version (calibration, QC), uniform sampling over decade
- ➢ Use overlapping single-instrument/single-processor series for climate analyses

NRT OSI SAF visualization at KNMI



- Considered as part of ESA MAXSS project
- Storm-centric tiles based on track predictions of TC and Polar Low?
- Dropsonde scale
- SMOS, SMAP, radiometers?
- High resolution, 5.6 km for ASCATs ?
- Maintenance in OSI SAF ?

ESA Marine Atmosphere eXtreme Satellite Synergy (MAXSS)

- IFREMER has scientific lead
- Tropical Cyclones (TC), extra-tropical cyclones (ETC), polar lows (PL)
- Integrate research and operational instruments: SMOS, SMAP, SSMI, AMSR, WindSat
- Integrated product (atlas)
- Intercalibration, production, visualization, monitoring
- Application in climate, nowcasting, NWP, ..
- Links to EUMETSAT OSI SAF, EU C3S, EU CMEMS

ESA MAXSS project WPs and SubWPs

- **WP1000** Scientific Requirements Consolidation and Dataset collection *B. Chapron (IFR)*
  - **WP1100** Scientific Challenge & State of the Art *A. Mouche (IFR)*
  - **WP1200** Review of On-going projects *M. Portabella (ICM/CSIC)*
  - **WP1300** User Consultation *H. Bonekamp*
  - **WP1400** Review of Approaches for building products *Ad Stoffelen (KNMI)*
  - **WP1500** Data Collection *J. F. Piolle (IFREMER)*
- **WP2000** Development *M. Portabella (ICM/CSIC)*
  - **WP2100** Methods and algorithms For multi-sensor High wind SWS *J. Tenerelli (ODL)*
  - **WP2200** Methods for multi-sensor High wind SWS Uncertainty estimation *M. Portabella (ICM)*
  - **WP2300** Methods for Ocean+ Extremes Atlas *N. Reul (IFR)*
  - **WP2400** Vizualisation tools *F. Collard (ODL)*
  - **WP2500** Methods for Added-Value Products *W. Perrie (BIO)*
  - **WP2600** Validation Metrics *Ad Stoffelen (KNMI)*
- **WP 3000** Ocean+Extremes Datasets Production and Validation *J.F. Piolle (IFR)*
  - **WP3100** Multi-mission wind gridded products production *J.F. Piolle (IFR)*
  - **WP3200** Multi-mission wind gridded products Validation *Ad Stoffelen (KNMI)*
  - **WP3300** User Manual for the multi-mission wind product *J.F. Piolle (IFR)*
  - **WP3400** Ocean+Extremes Atlas Production *N. Reul (IFR)*
  - **WP3500** Ocean+Extremes Atlas Validation *F; Soulat (CLS)*
  - **WP3600** User Manual for Ocean+Extremes Atlas *N. Reul (IFR)*
  - **WP3700** Added Value Product Production *J.F. Piolle (IFR)*
  - **WP3800** User Manual for Added Value products *A. Mouche (IFR)*
- **WP4000** Scientific Analysis *J. Shuttler (U. Exceter)*
  - **WP4100** Investigate the last 10 years changes in extreme winds *Ad Stoffelen (KNMI)*
  - **WP4200** Assessment of the impact of extreme wind events On the ocean *W. Perrie (BIO)*
  - **WP4300** Assessment of storm impact on ocean biogeochemistry *J. Shuttler (U. Exceter)*
- **WP5000** Impact Assessment *A.Stoffelen (KNMI)*
  - **WP5100** Comparisons With existing products *M. Paola Clarizia (Deimos)*
  - **WP5200** Errors/uncertainty Analyses *Ad Stoffelen (KNMI)*
- **WP6000** Scientific Roadmap *J. Johanessen (NERSC)*
- **WP7000** Outreach & Com *A. Mouche (IFR)*
  - **WP7100** Project Web Site *J.F. Piolle (IFR)*
  - **WP7100** Outreaching: Publications, training & Workshop *F. Collard (ODL)*
- **WP8000** Management H. Bonekamp