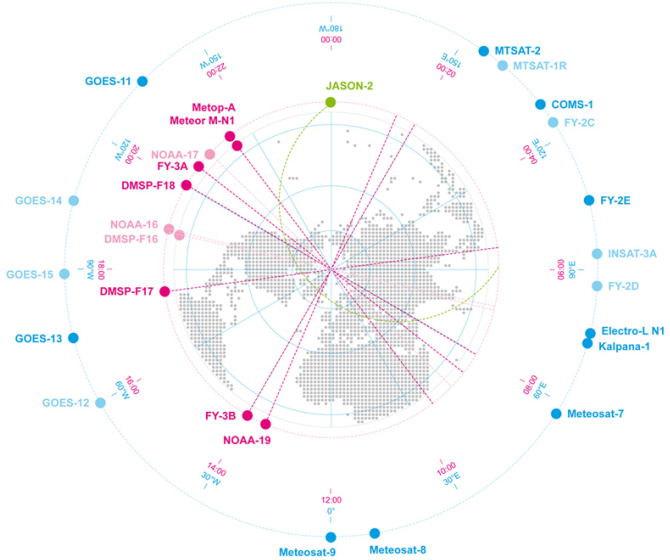

Satellite Measurements of Ocean Surface Waves

Presented to CGMS-45 Plenary, Session C.8

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Objective

Contributions of ocean surface wave measurements to global surface wave forecasts and global NWP products?

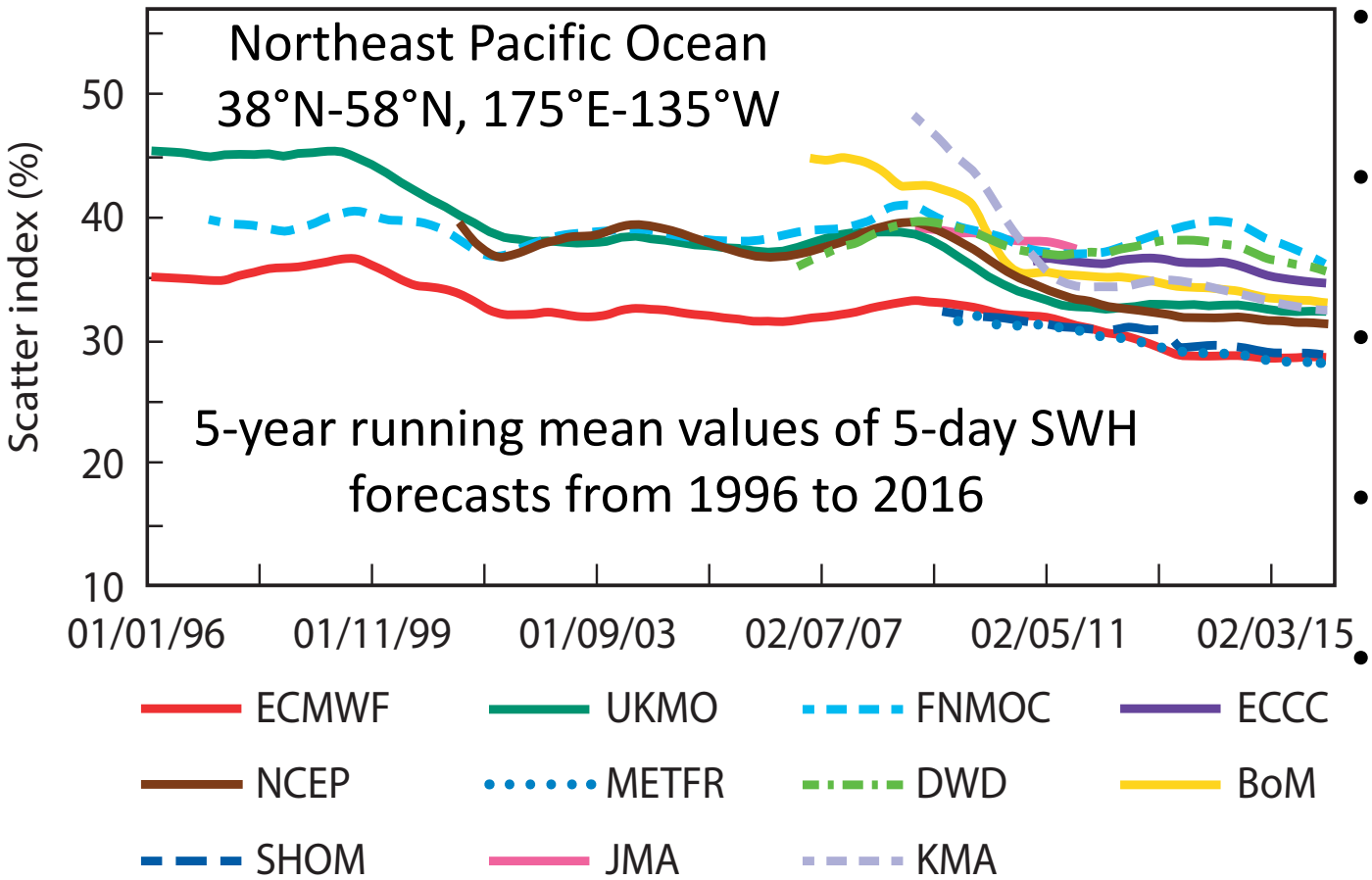
Significant Wave Height (SWH)

- Mean trough-to-crest height of the highest third waves
- Four times the standard deviation of surface height
- Four times the integral of wave spectrum

Sea and Swell

- Sea = surface waves generated by local wind
- Swell = surface waves radiated from wind sea

Progress of Global Wave Model Performance

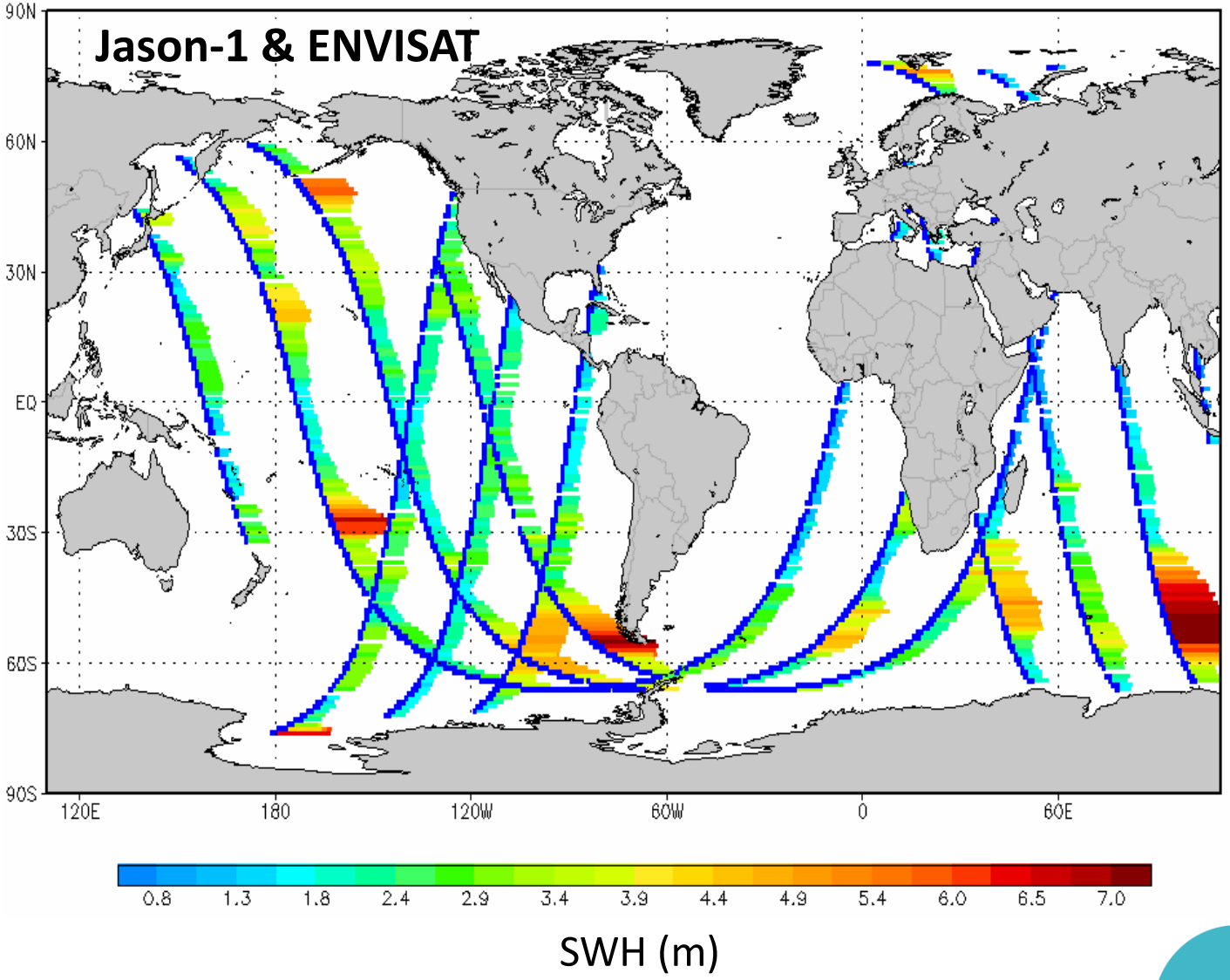


- **No assimilation of satellite data**
- Referenced to in-situ data at 19 buoy sites
- At initial time, 2016 range of S.I. = 12-20%
- Day-5 forecast, 2016 range of S.I. = 30-38%
- ECMWF winds used by SHOM (Service Hydrographique et Océanographique de la Marine de France) and METFR (Météo France)

- Slow, steady, incremental progress in NE Pacific
- No improvement in Western Mediterranean Sea

Bidlot (2016)

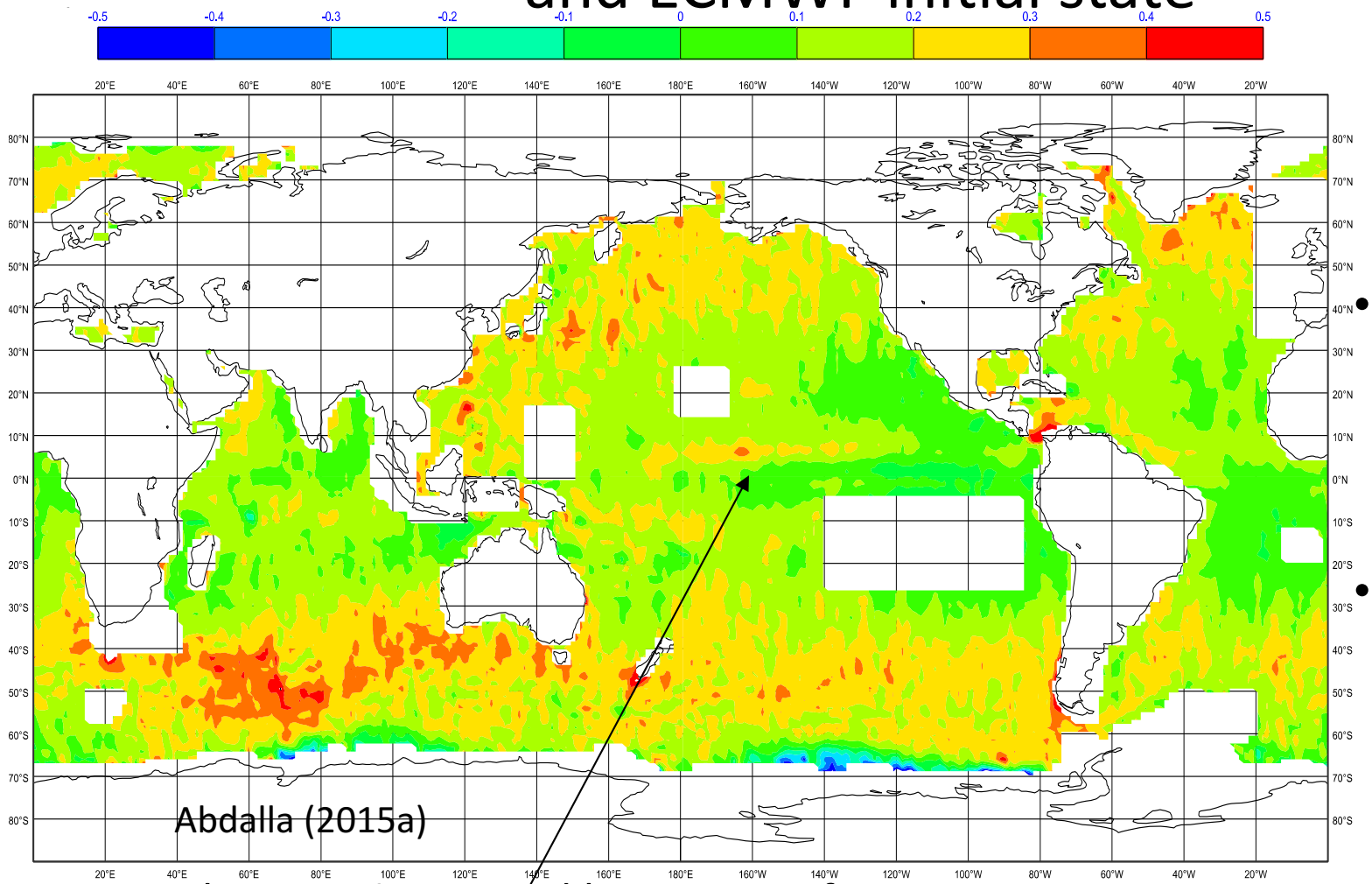
6-h Sampling Distribution From Two Satellite ALT



- Many storms would be undetected
- A SWH value is computed in 1 s (5-7 km) by averaging 100s – 2000 pulses
- In operational wave models, 10 SWHs (super-observation) averaged alongtrack
- First NRT SWH by ERS-1 in 1991

Lefevre et al. (2006)

1-y mean SWH bias (m) between 6-hr averaged CryoSat-2 ALT and ECMWF initial state



- Bias = 5% or 2.5 cm for SWH of 0.5 m (older ERS-1 data, 10%)
- Trend in N. Atlantic = 2.5 cm/y (Bouws et al., 1996)
- Non-uniform geographical distribution, e.g., Southern Ocean

- Large bias at 5°N caused by impact of currents on ocean surface waves

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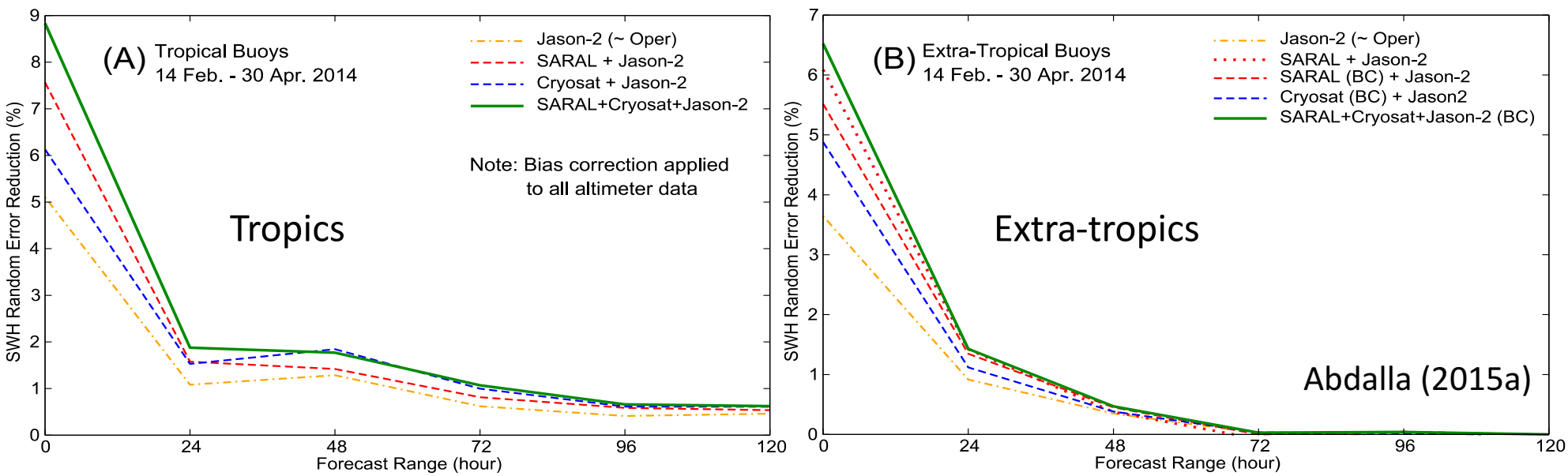
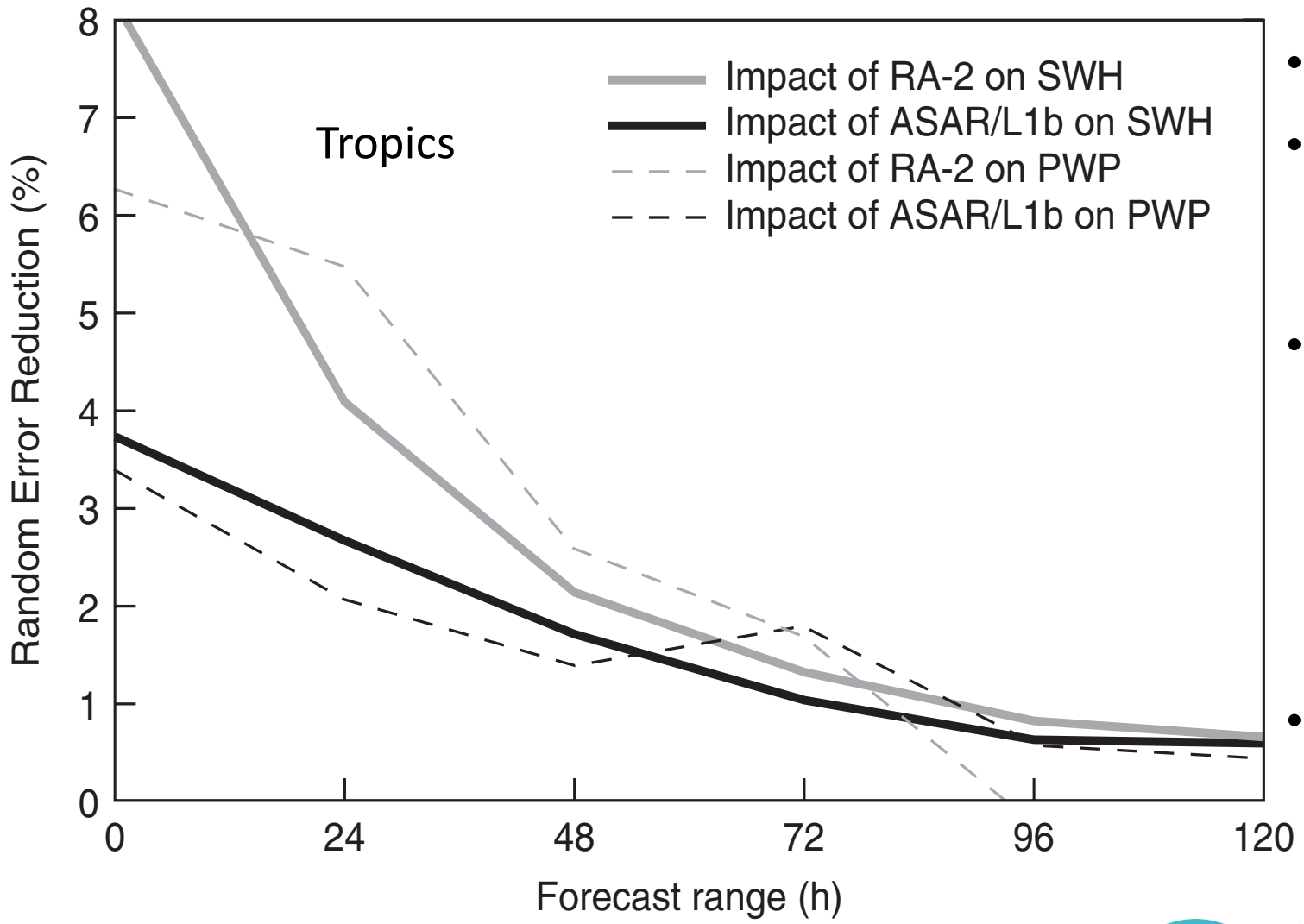
ALT SWH Data Assimilation Impact on ECMWF SWH

- Accuracy of initial wave forecast increased with the number of satellite altimeters
- Influence of multiple satellite ALTs was negligible at forecast times > 1 day
- Assimilation of SWH data has a longer (shorter) memory in the tropics (extra-tropics) where local wind has less (more) of an influence.
  - In the tropics, swell is an important component of surface waves and local wind is not related to swell



Impact of ALT and SAR SWH on ECWAM Forecasts



- ENVISAT
- Referenced to in-situ buoy data
- At initial state, ALT impact was twice larger than SAR impact
- At 1 day, ALT impact was 20% greater

- PWP = peak wave period

Dragani et al. (2014)

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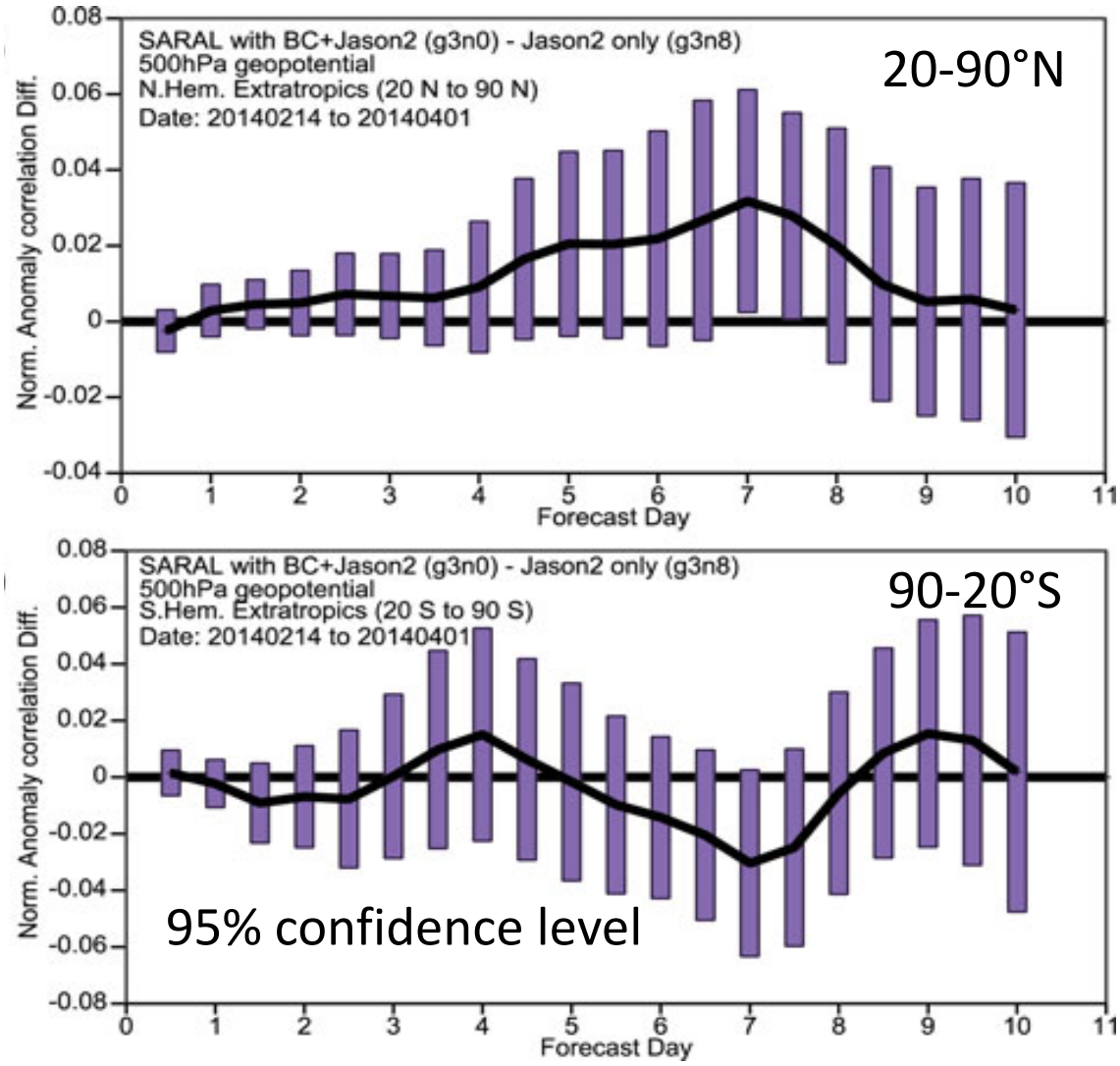
CGMS

Assimilation of Satellite SWH into NWP Forecasts



- Assimilation of SWHs from 2 ALTs compared to 1 ALT into ECMWF wave model coupled to ECMWF NWP forecast system did not significantly change the forecast skill of 500-hPa geopotential height within 95% confidence.
- 80% of ECMWF surface wave forecast is determined by accuracy of surface wind field
- Ocean surface vector wind field, research challenges and operational opportunities, was described in CGMS-40 IOC-WP-01

Abdalla (2015b)

Summary

- Satellite ALT SWH data and buoy data differ, global average, 5%
- Assimilation of NRT ALT data from 1 ALT in ECWAM reduces error in initial state by 3-4% compared to in-situ buoy data. Assimilation of NRT ALT data from 2 and 3 ALTs reduces error in initial state by additional 2% and 4%, respectively.
- Current capacity of NRT SWH is 3-4 systems
  - Present (Jun 2017): Jason-2 (Jun 2008), CryoSat-2 (Apr 2010), SARAL (Feb 2013), Jason-3 (Jan 2016), Sentinel-3A (Feb 2016)
  - Future (until 2020): Sentinel-3B (Nov 2017), CFOSAT (2018), Sentinel-6A or Jason-CS (2020), Sentinel-3C (2020+)
- Assimilation of ALT SWH has little impact on ECWAM forecast beyond 1 day
- Assimilation of satellite ALT SWH has almost no statistically significant impact on skill of ECMWF 500-hPa geopotential height

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