Rediscovery of the doldrums in storm-resolving simulations over the tropical Atlantic

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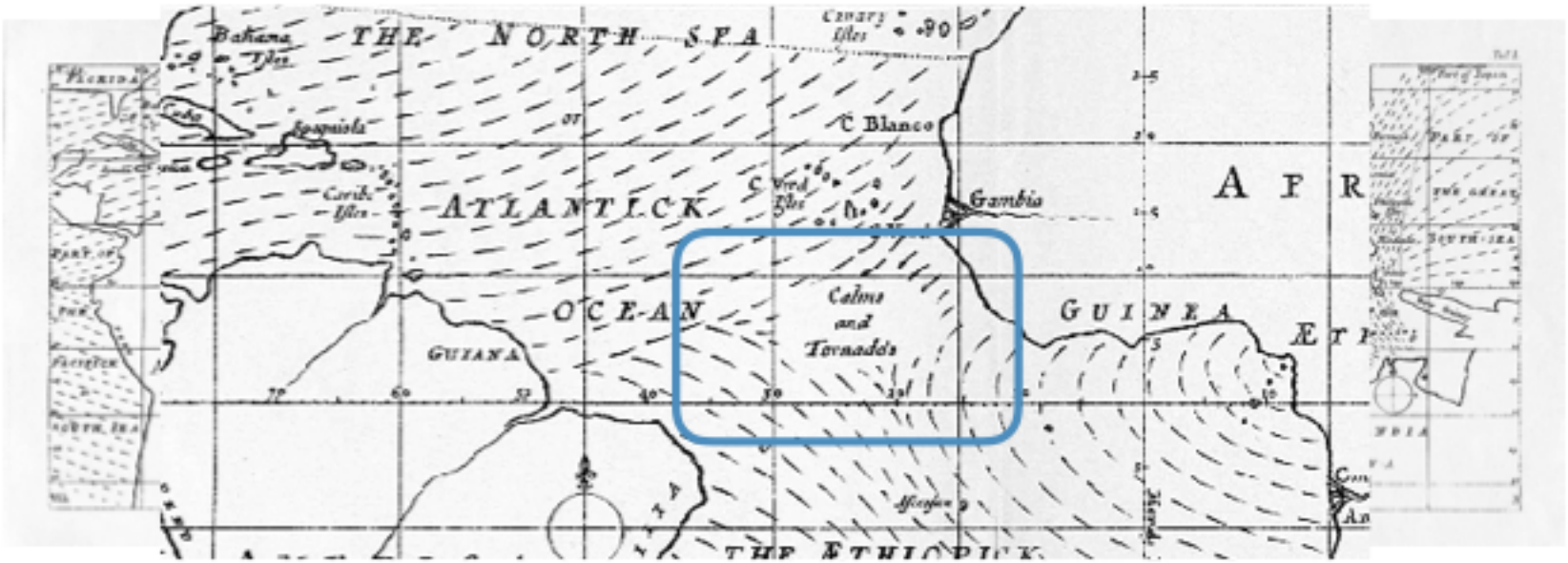
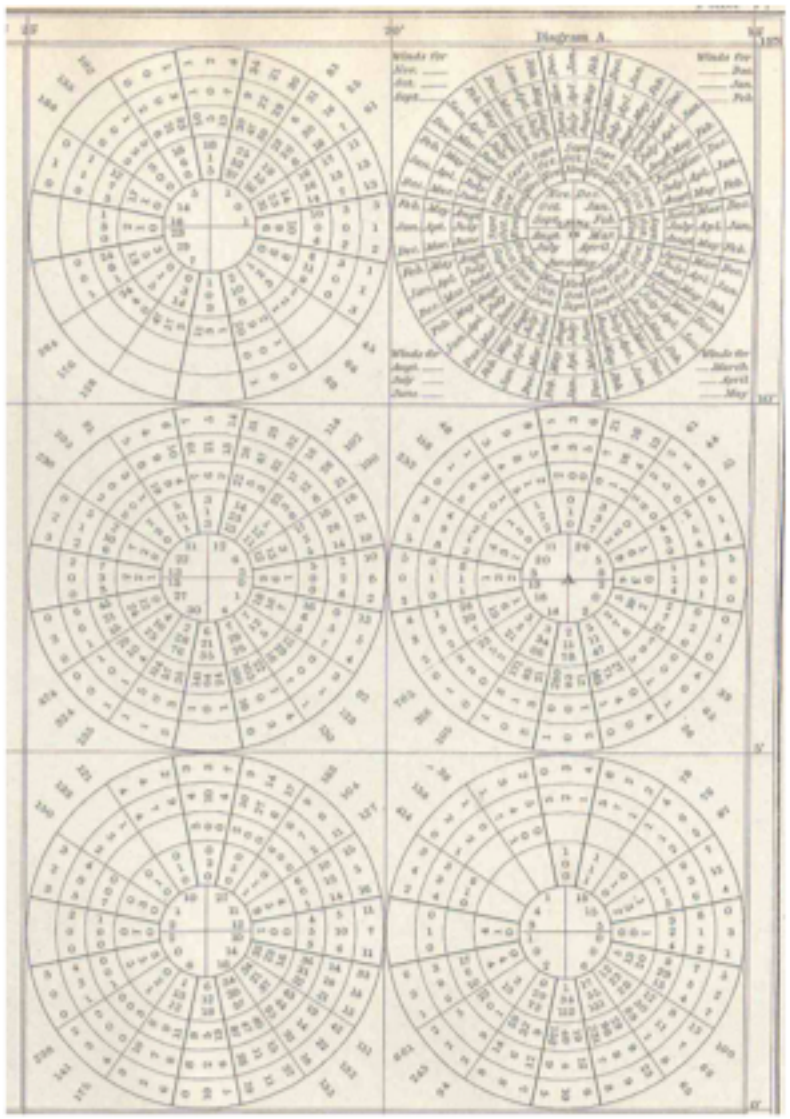
„Calms and Tornados“

‚perpetual calms attended with terrible thunder and lightening and rains so frequent, that our navigators from thence call this part of the sea the *Rains*.‘



Halley, 1686



Maury charts, based on ship observations

The motivation was to increase sailing ship travel speeds to make trading more efficient.

Maury, 1854

Doldrums

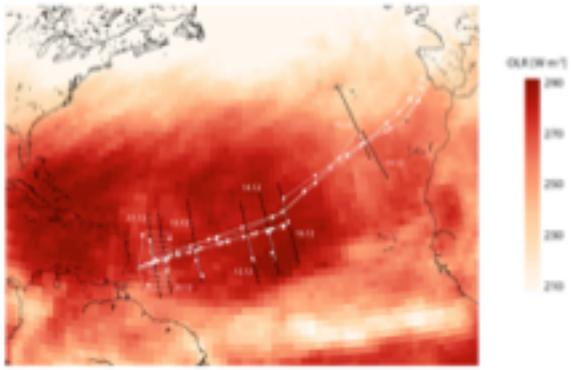
Steam ships start to dominate the oceans shortly after

Maury, 1864

BCO, NARVAL-I + II, EUREC^{4}A

Test hypotheses related to the interplay between clouds, convection and circulation and their role in climate change

NARVAL-I December 2013



8 Flight days

NARVAL-II August 2016

10 Flight days

Horizontal resolution

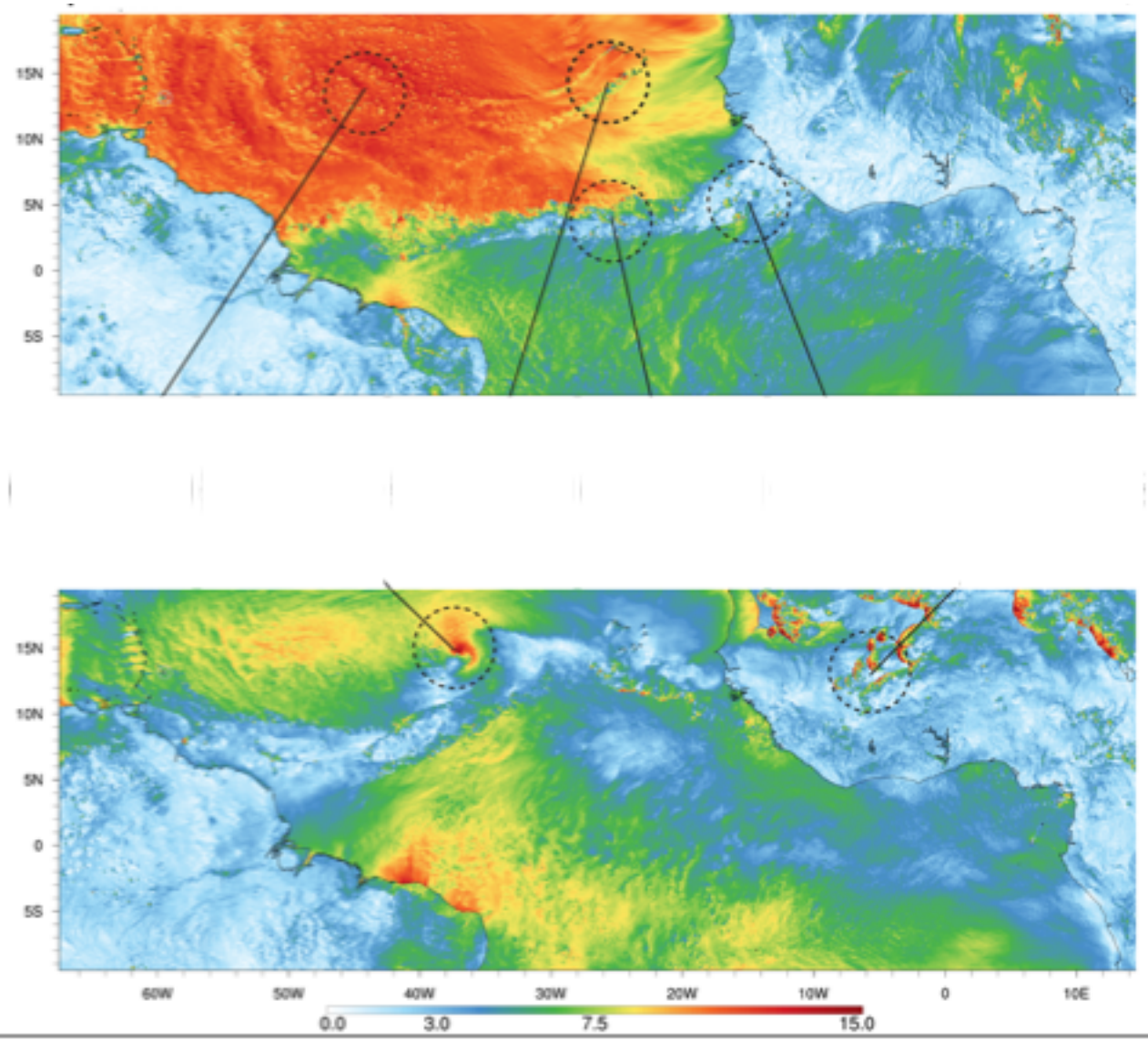
2,5 km
1,2 km

Setup:

ICON with NPW physics (no sso, gwd, convection) +Graupel in micro-physics
36h hind-casts for 74 days, initialized at 00 UTC (12/2013 and 08/2016)
Initialized and nudged with IFS
hourly 3d output, 30 minutes 2d output, 75 level, top at 30 km

Grid name	Resolution (m)	Grid points	dt	Norther boundry	Southern boundary	Western boundary	Eastern boundary
DOM01	2475	4887488	24s	20°N	10°S	68°W	15°E
DOM02	1237	3793024	12s	18°N	4°S	64°W	42°W

Wind speed 10 m m/s

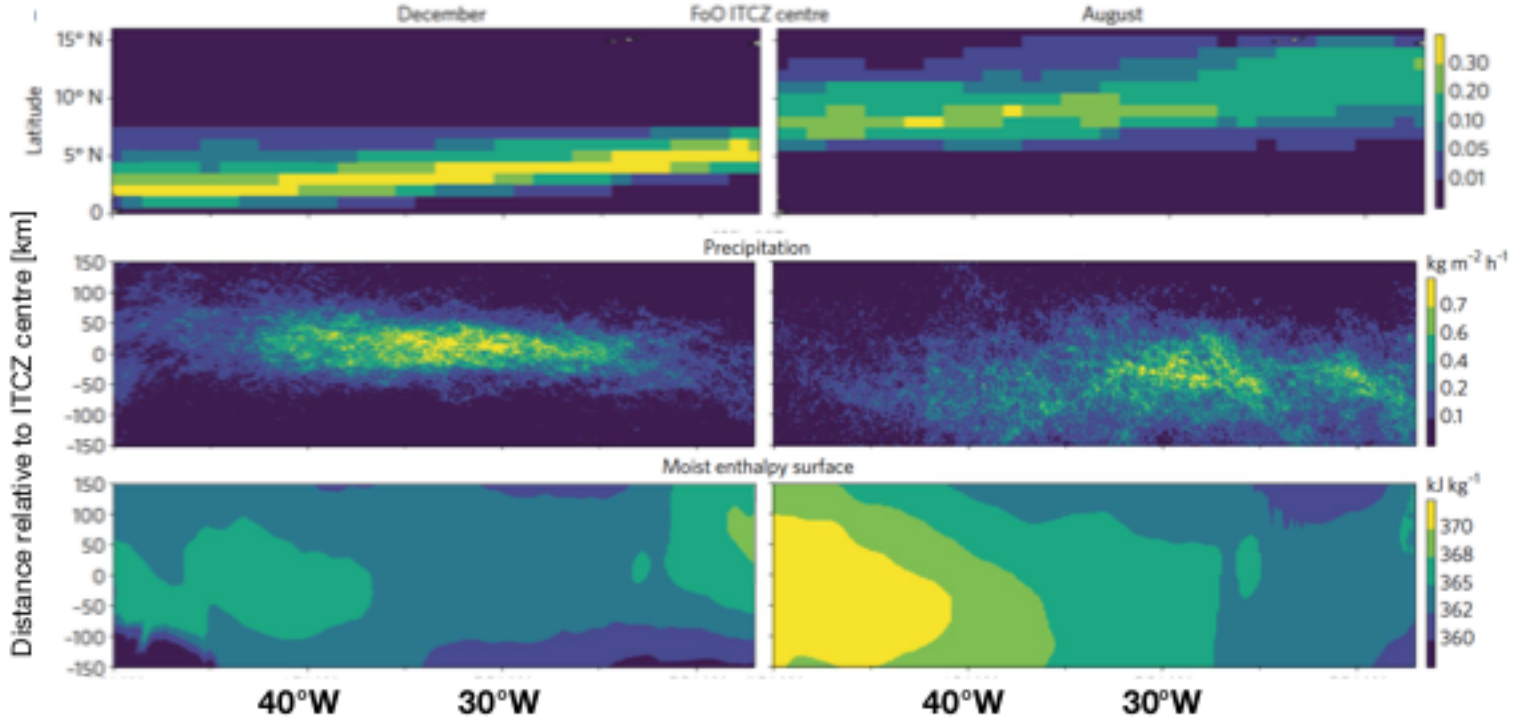


Klocke et al, 2017

Composite ITCZ

Minimise a cost function to define ITCZ center and composite on it: low wind speed, higher near surface convergence and relative humidity are more ITCZ.

$$J = 2u_{10\mathrm{m}} + 4v_{10\mathrm{m}} - 1.5\partial_y v_{10\mathrm{m}} - 0.05RH$$



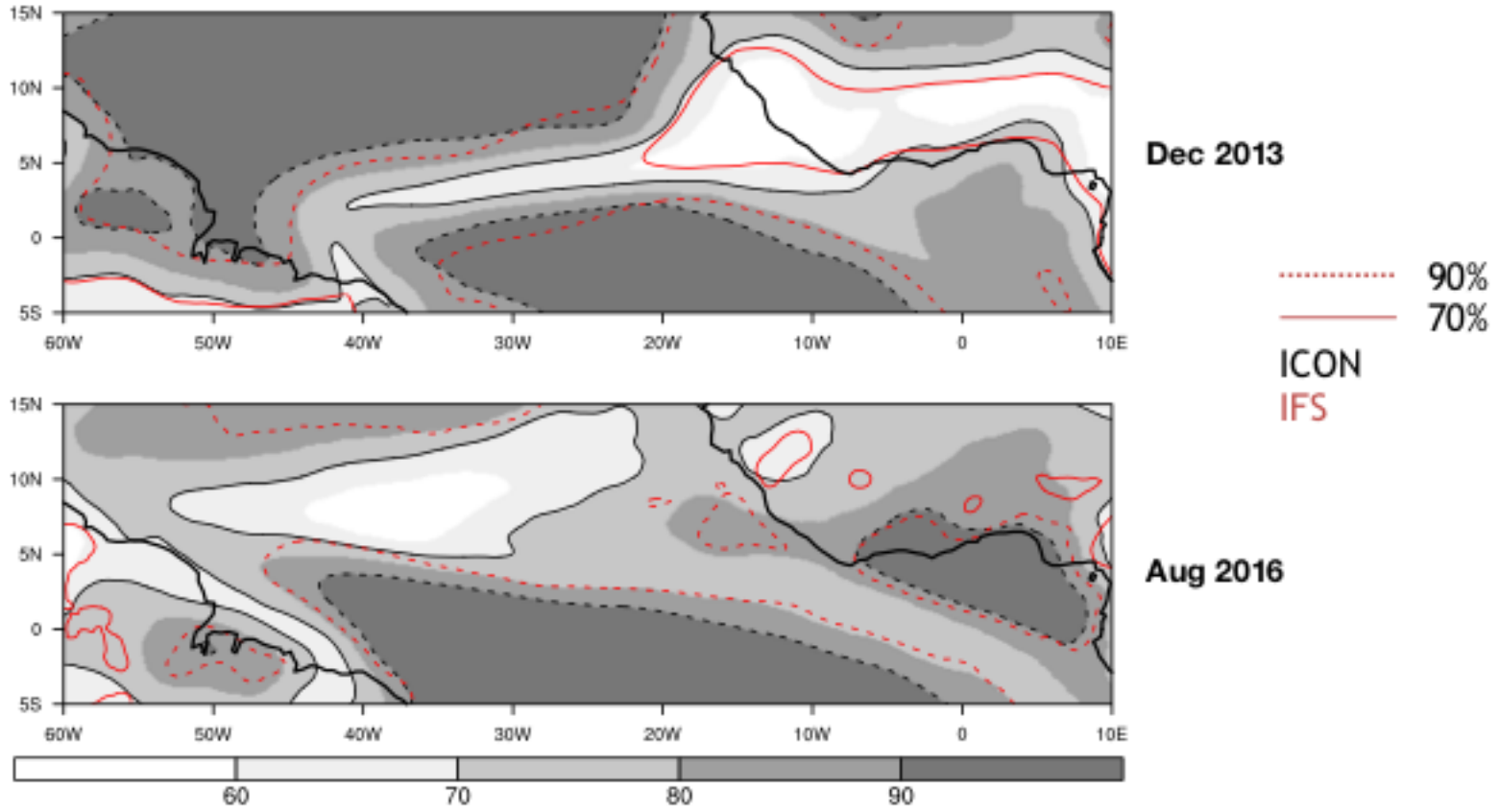
It rains where SSTs are coldest and one the winter side of the doldrums, where wind are strongest.

GCMs fail to simulate the precipitation in the central Atlantic, but mostly rain over warmest SSTs.

Klocke et al, 2017

Variability of wind, Doldrums

Variability of wind, Doldrums

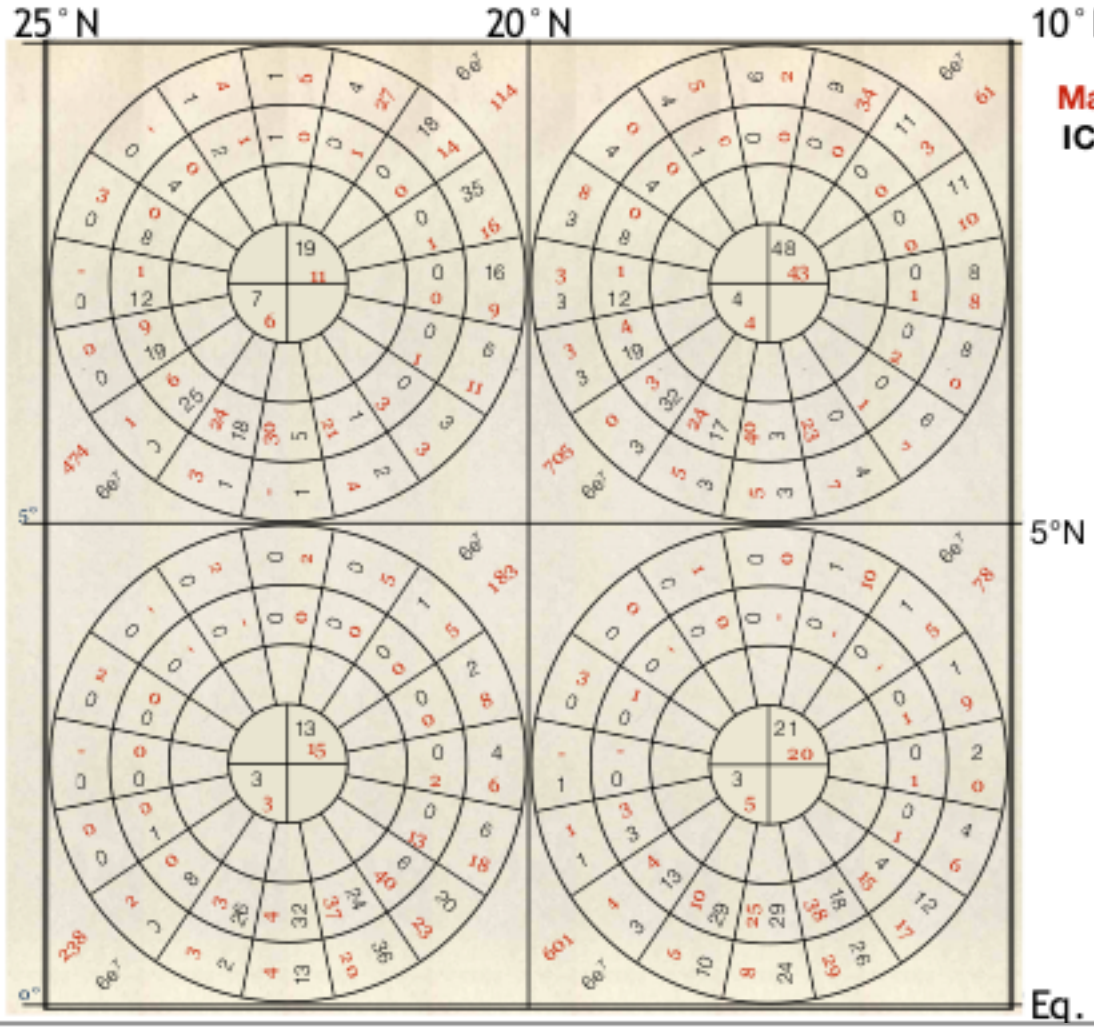


Percentage of time the wind is blowing in the dominant wind direction

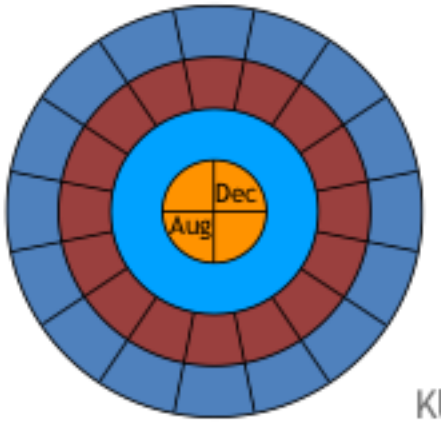
Klocke et al, 2017

Seeing old things in new ways with ICON

.. but we can also look at new things in the old ways



Maury 1864
ICON 2016



Calms (< 3 m/s)

December

August

Klocke et al, 2017

The doldrums are a prominent feature of the general circulation. They faded from the scientific focus.
-> focus shifted to the rain systems forming within the doldrums.

Cloud resolving simulations of the tropical Atlantic show a strong coupling between wind and convection, with the doldrums as one of the most prominent features.
-> rain (ITCZ) forms on the outer boundaries of the doldrums and over the coldest SSTs (unlike in GCMs).

A parameterized model (with relatively high resolution) struggles to reproduce characteristics of this large scale feature. Maybe long standing biases in GCMs are related to the misrepresentation of the interplay of convection and wind.

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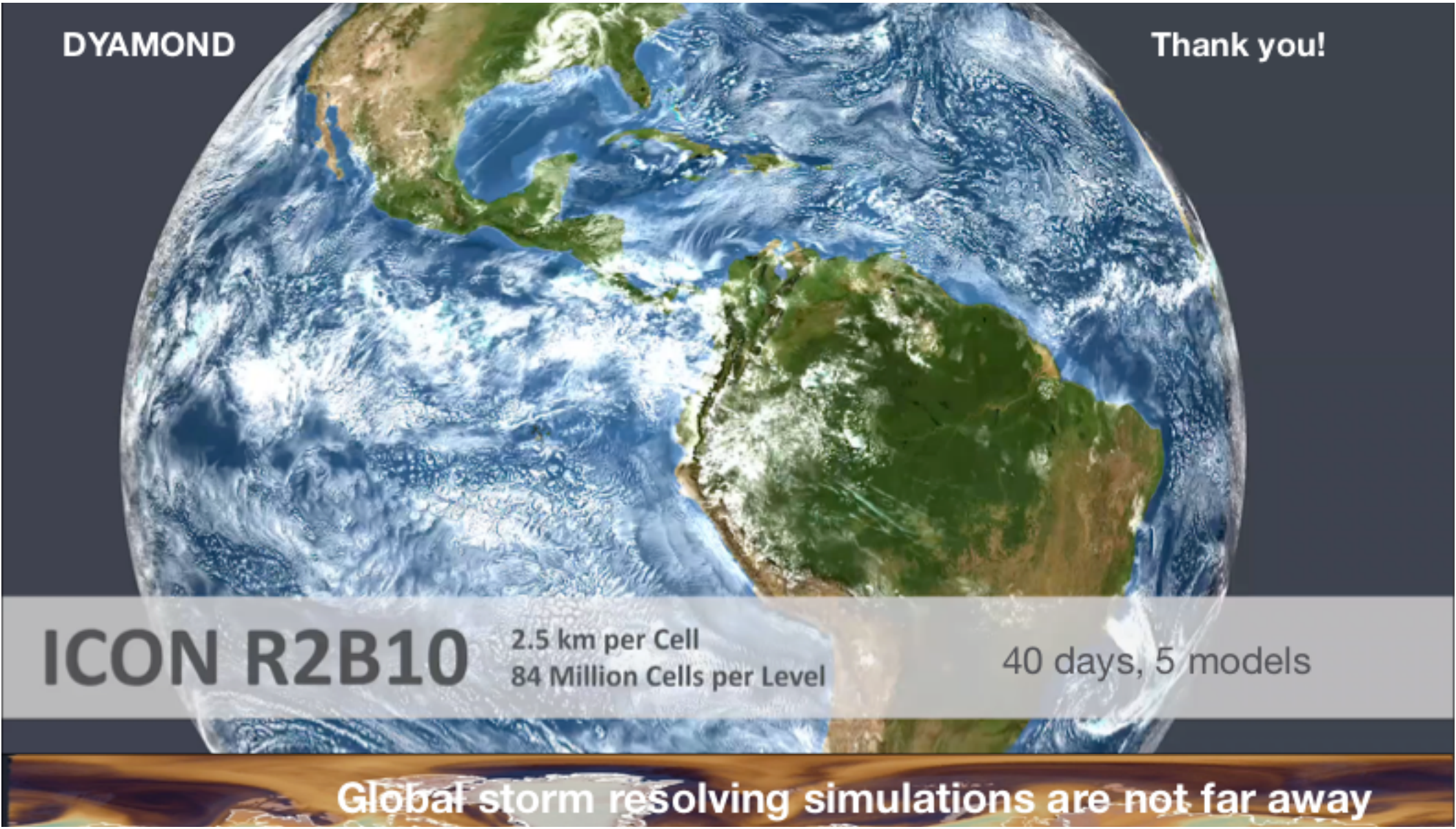
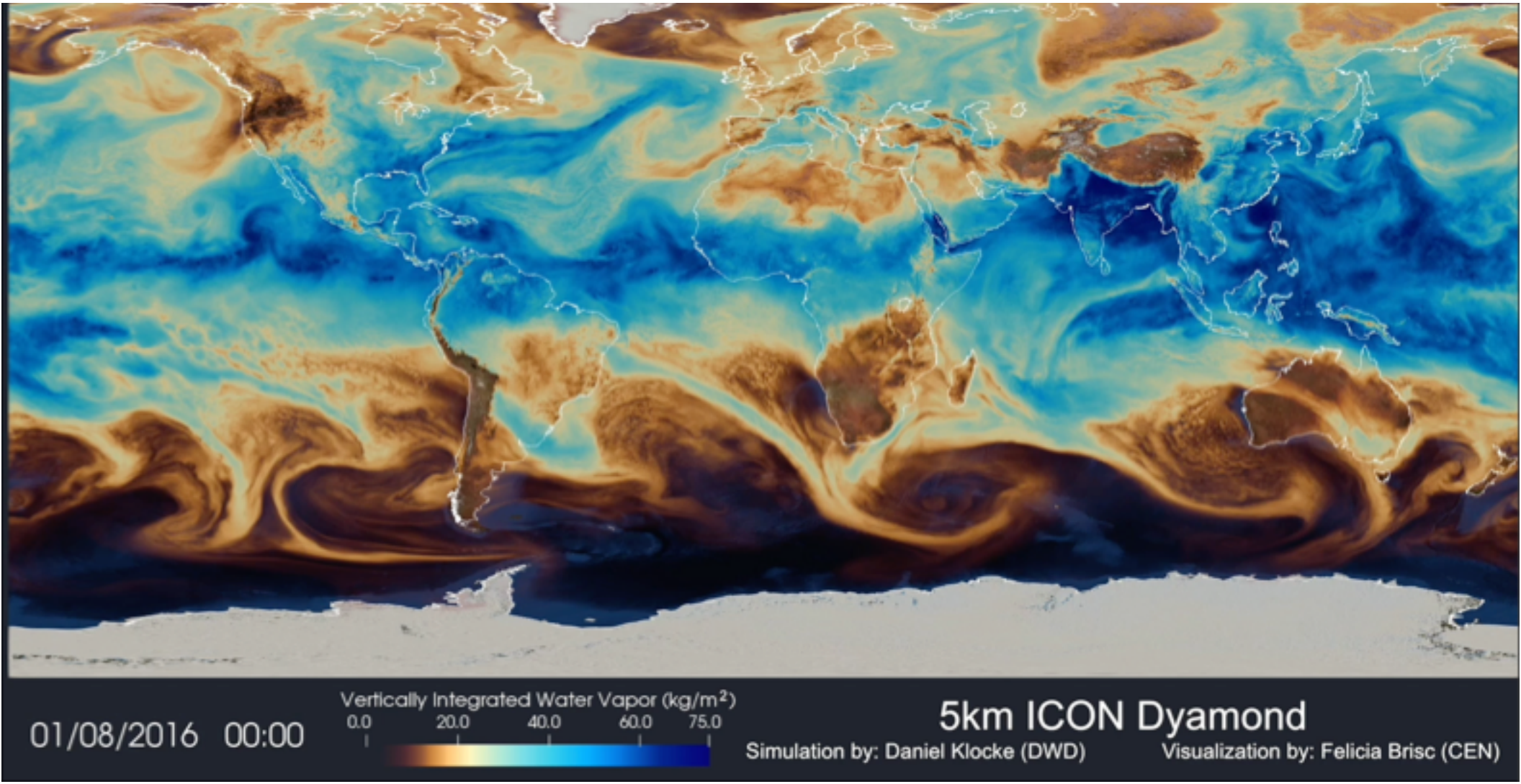

DYAMOND
Thank you!
ICON R2B10
2.5 km per Cell
84 Million Cells per Level
40 days, 5 models
Global storm resolving simulations are not far away


01/08/2016 00:00
Vertically Integrated Water Vapor (kg/m²)
0.0
20.0
40.0
60.0
75.0
5km ICON Dyamond
Simulation by: Daniel Klocke (DWD)
Visualization by: Felicia Brisc (CEN)