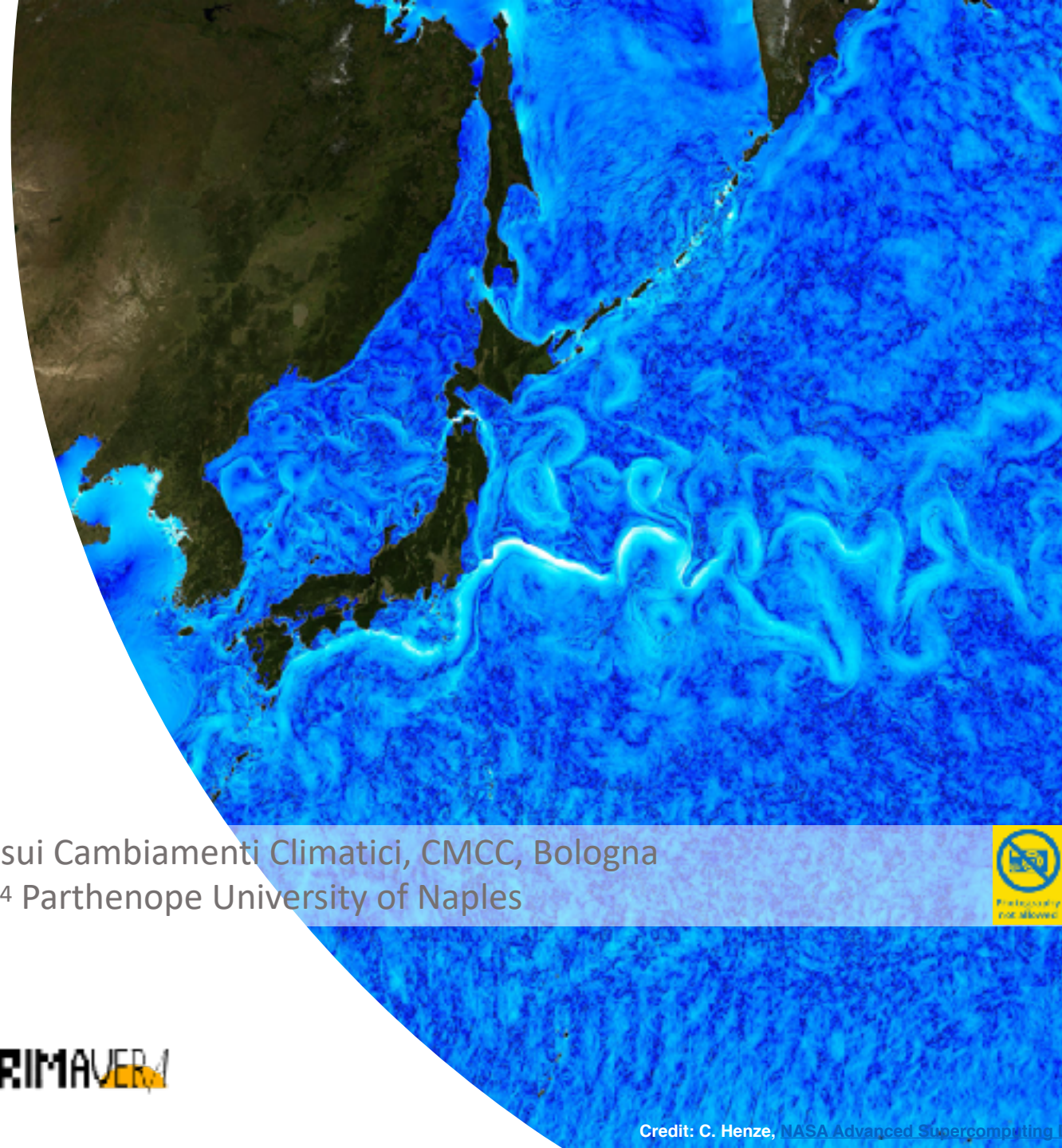




ANALYSIS OF THE KUROSHIO EXTENSION DECADAL VARIABILITY : Internal Mechanisms and External Forcings

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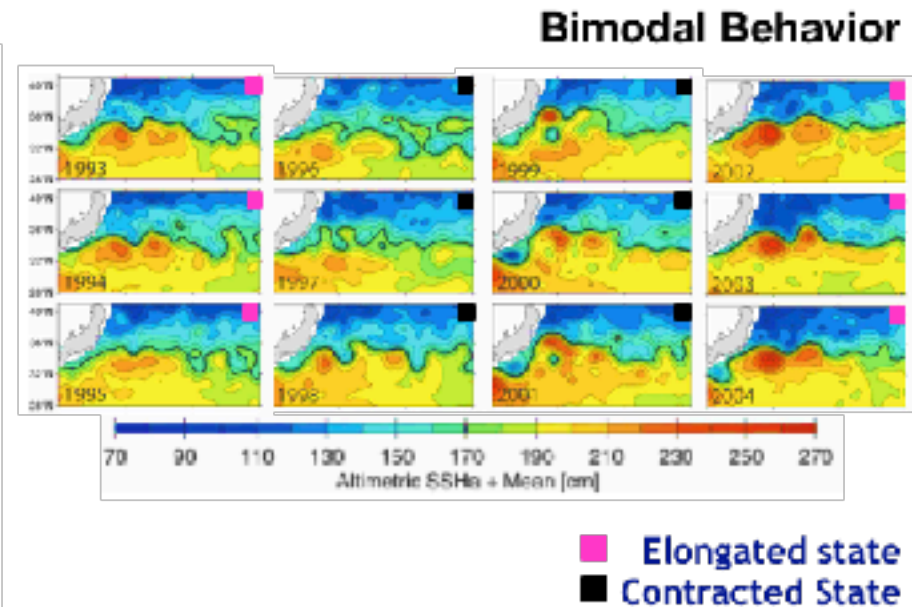
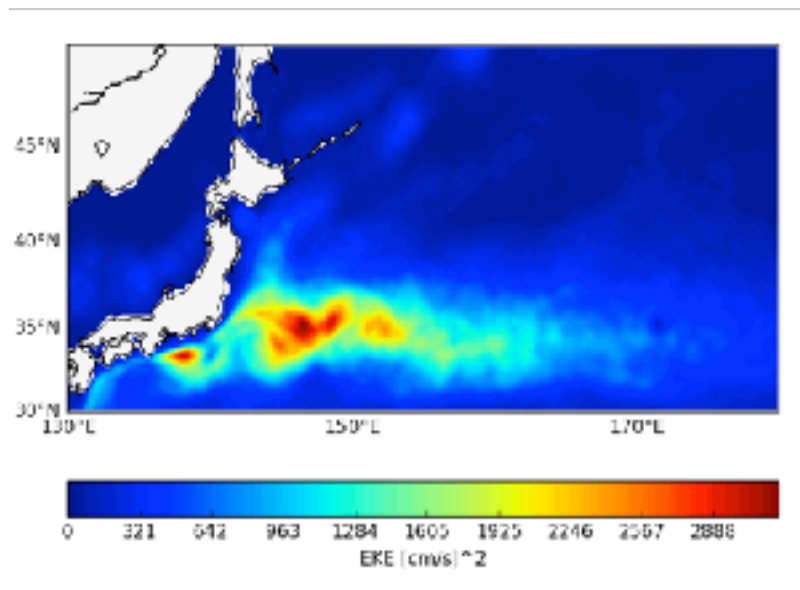
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Venezia



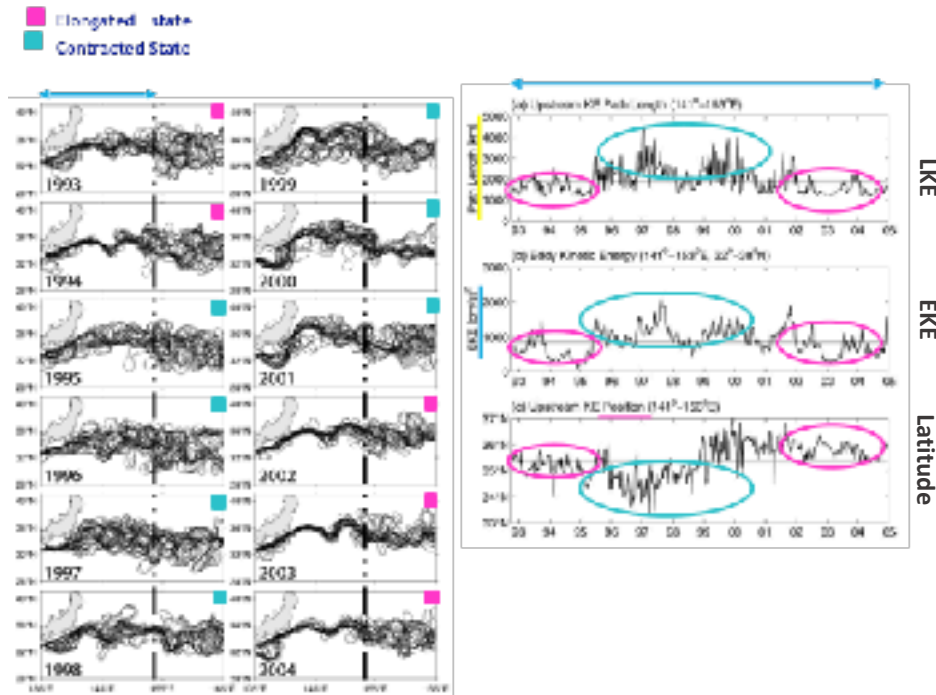
PRIMAVERA

Why study the Kuroshio Extension (KE) from a Climatic Point of View?

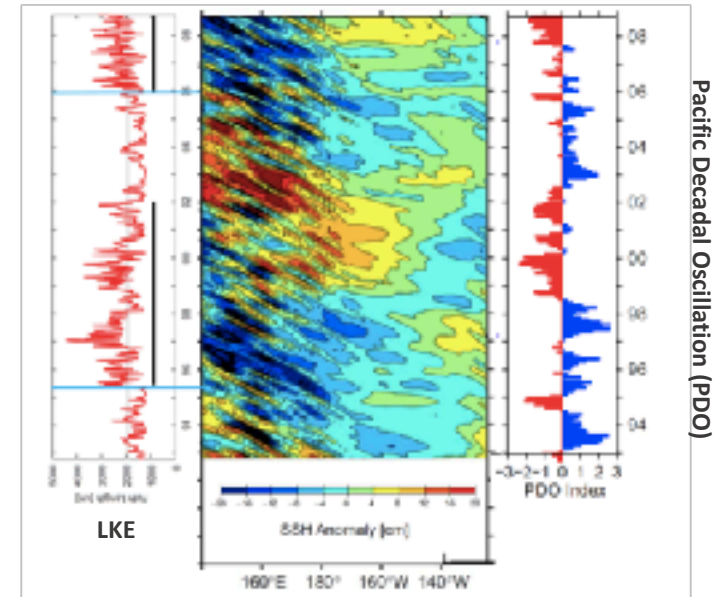
- Highest eddy kinetic energy level (EKE) in the North Pacific Ocean. EKE changes lead to high temperature anomalies that are capable of enhancing the variability of the midlatitude coupled ocean-atmosphere system.
- The KE is known to undergo relevant variations on the decadal time scale. The mechanisms that generate the mean structure of the KE and its low frequency variability (LFV) are still under debate.



Frontal Variability (FV)



Broad-Scale Variability (BV)



- Synchronization with external forcings (Qiu and Chen, 2005,2010).
- Many authors have suggested that nonlinear intrinsic oceanic mechanisms can play a fundamental role in the phenomenon (Pierini, 2006).
- The KE LFV is interpreted as a case of intrinsic climate variability paced by external forcing through the coherence resonance mechanism (Pierini, 2014).

QUESTION

What is the role of the intrinsic variability and external forcing in driving the KE LFV?

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METHOD

To explore a *large* ensemble of ocean-only eddy-permitting model simulations: OCCIPUT

OCCIPUT*

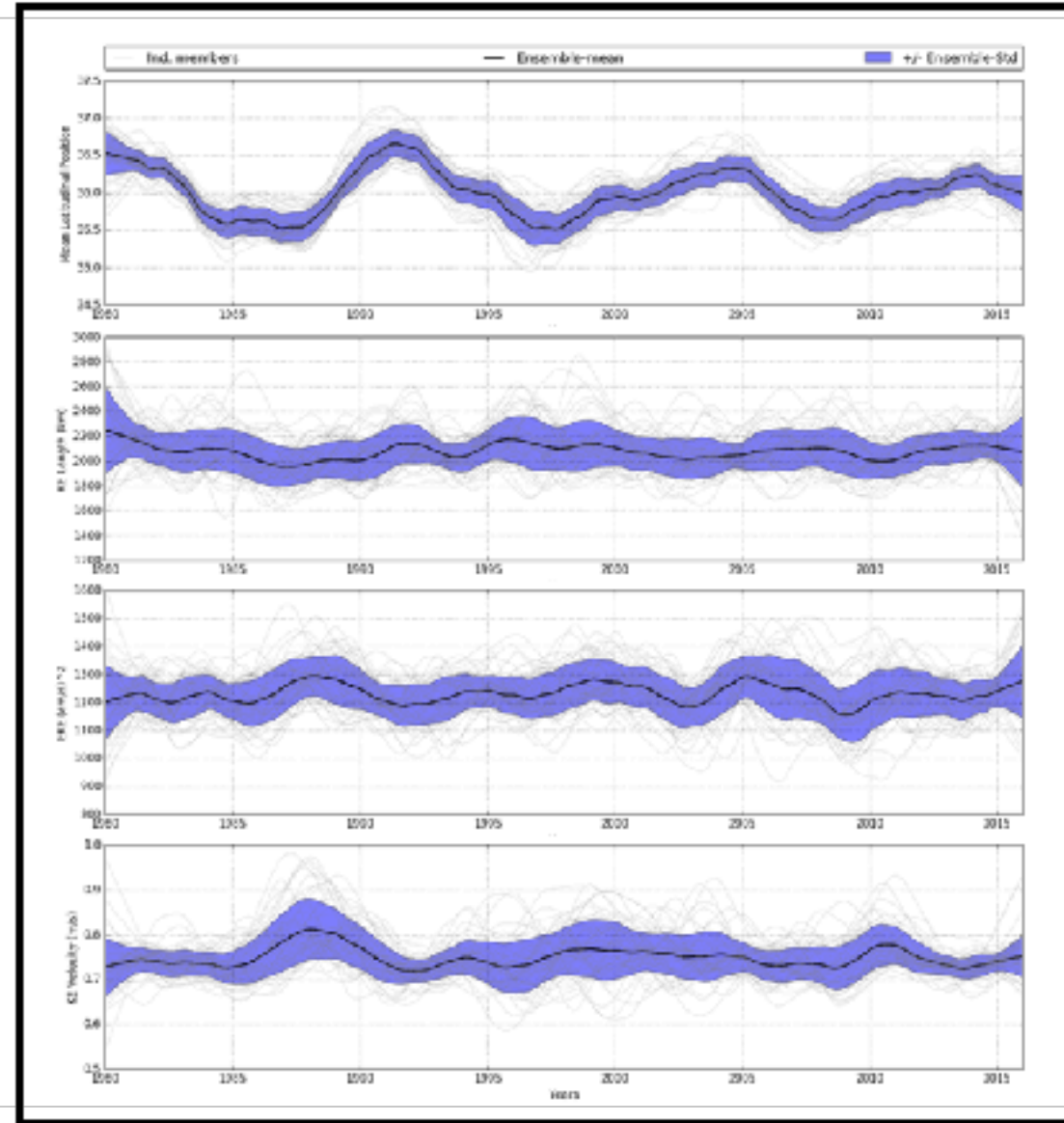
SIMULATION	EXTENT AND RESOLUTION	MEMBERS AND DURATION	FORCING	SIMULATED VARIABILITY	TIME SAMPLING
OCCITENS	Global 1/4°	50-members ENSEMBLE 1980-2015	Full variability (ERA-interim)	Forced and intrinsic variability	5 days
OCCICLIM	Global 1/4°	1 member 300 years	Climatological Seasonal Cycle	Pure intrinsic variability	5 days

*Penduff et al. (2014) and Bessières et al. (2017)

Reference SSH isoline of the jet 0.7 meters

Average in the box (141-153°E, 32-38°N)

Max total geost. velocity in the box
(141-153°E, 30-40°) integrated zonally



Latitude

LKE

EKE

KE Velocity

Time

Gaussian metrics are appropriate since the climatological PDFs for these variables are pretty gaussian

We take advantage of some definitions and notations (Leroux et al., 2018):

$$f_i(t) = \langle f_i(t) \rangle + f'_i(t)$$

We define $f_i(t, j)$ as every index after nonlinear detrending, where t stands for the time (yr) and i is the index of the ensemble member. We use overbars for the time-mean operator and angled brackets for the ensemble-mean operator.

$$\begin{cases} A_{intrinsic} = \sqrt{\varepsilon^2} \\ A_{forced} = \sigma(f) \\ A_{tot, i} = \sigma f_i \\ R = \frac{A_{intrinsic}}{A_{forced}} \end{cases}$$

$\varepsilon^2(f)$: the time variance operator applied to the ensemble mean

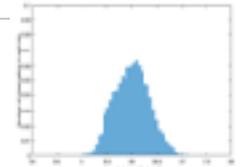
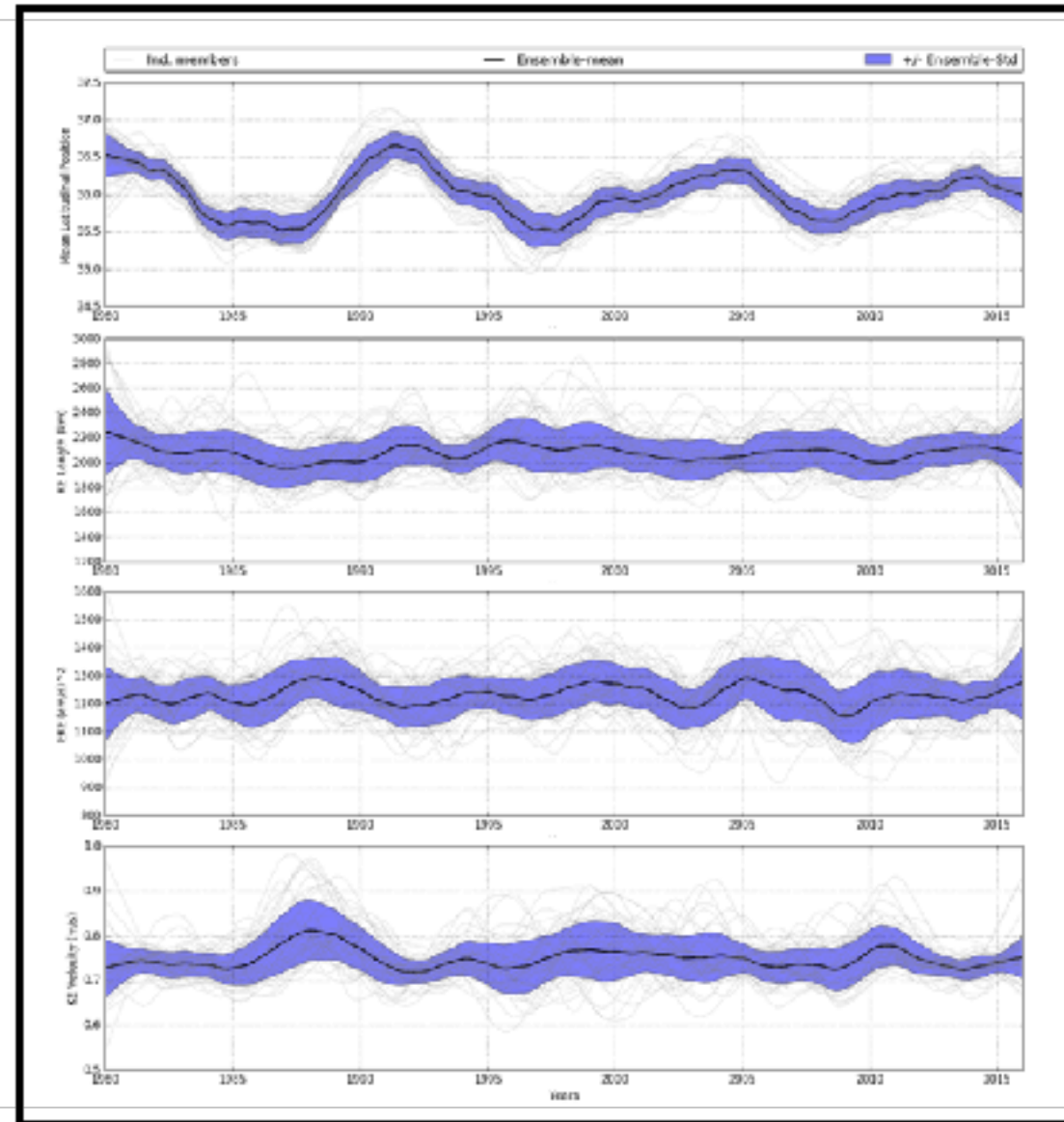
$\varepsilon^2(t)$: ensemble variance operator applied to $f(t)$

$A_{intrinsic}$: Amplitude of the intrinsic variability

A_{forced} : Amplitude of the forced variability

A_{tot} : Amplitude of the total variability in each member

R : Amplitude Ratio



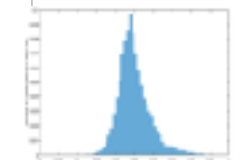
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LKE



EKE



KE Velocity

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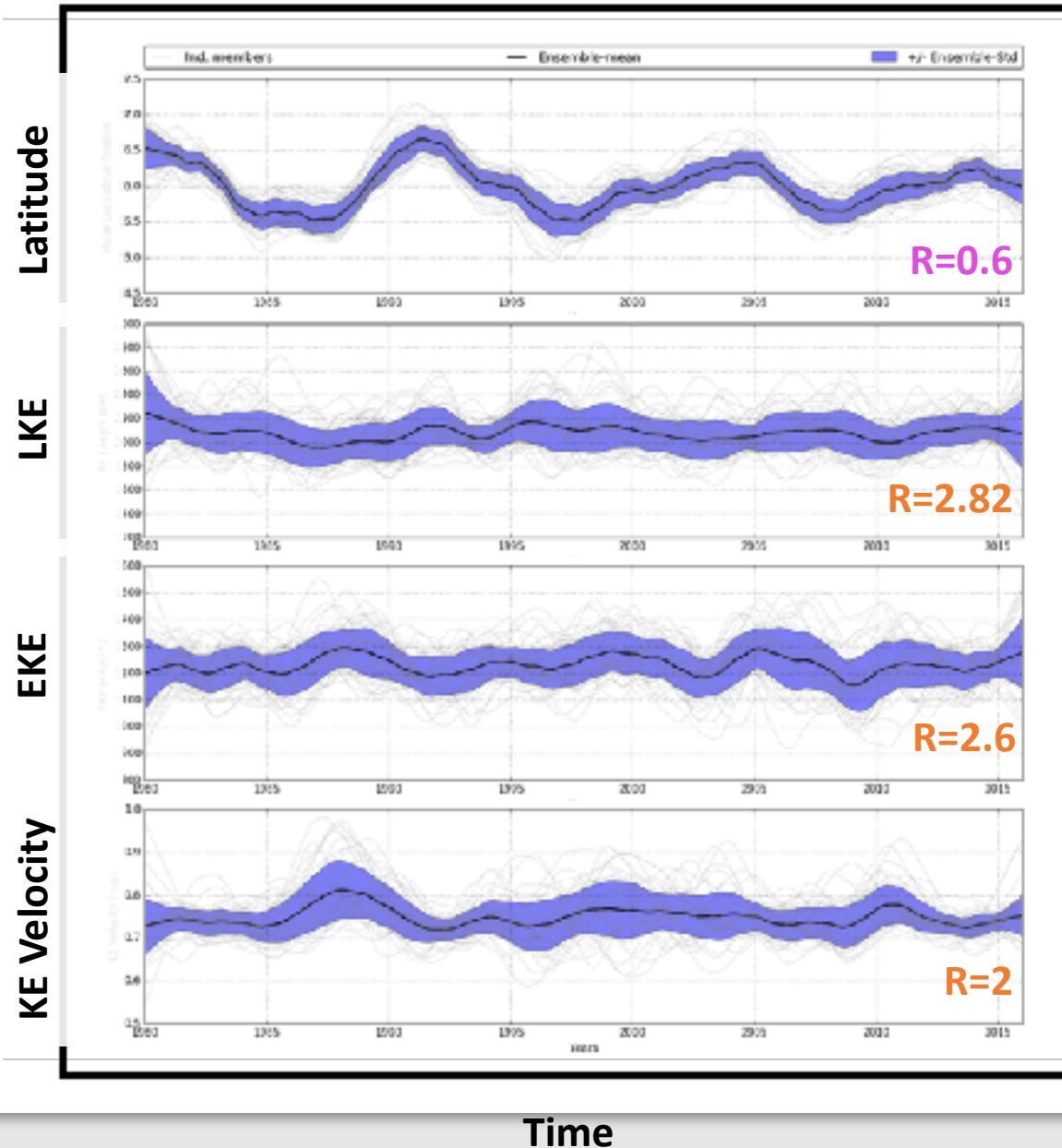
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■ $A_f > A_i$

■ $A_i > A_f$

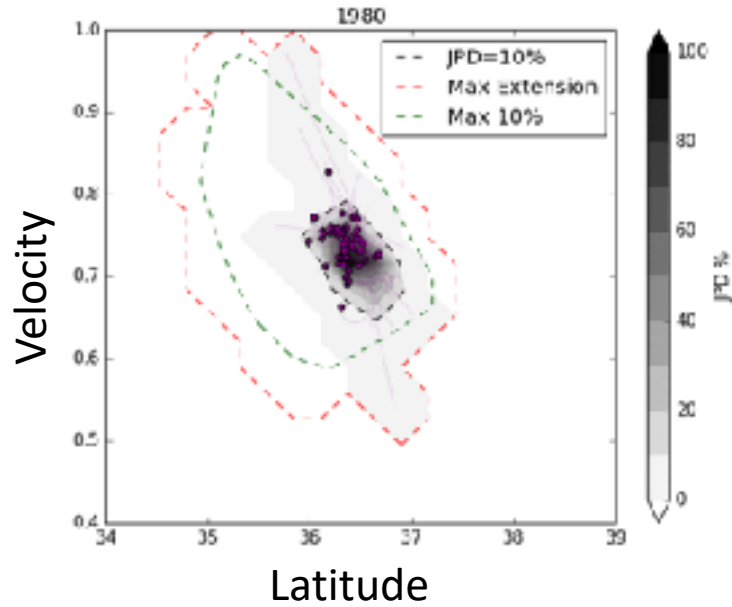
**Pure intrinsic
variability****EXTENT AND
RESOLUTION**

Global 1/4°

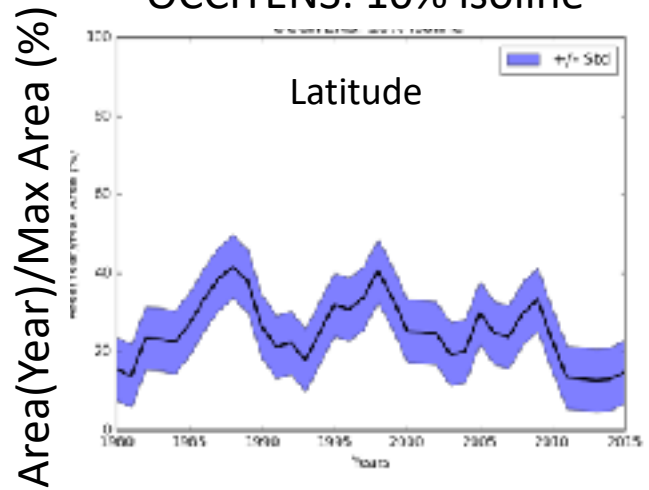
**MEMBERS AND
DURATION**1 member
300 yrs**FORCING**Climatological
Seasonal Cycle**TIME
SAMPLING**5
days**STRATEGY:****TO CREATE A PSEUDO-ENSEMBLE FROM OCCICLIM**

50 members x 36 yrs have been built randomly from the indices already computed, in order to compare the pure intrinsic variability with the total one given by OCCITENS.

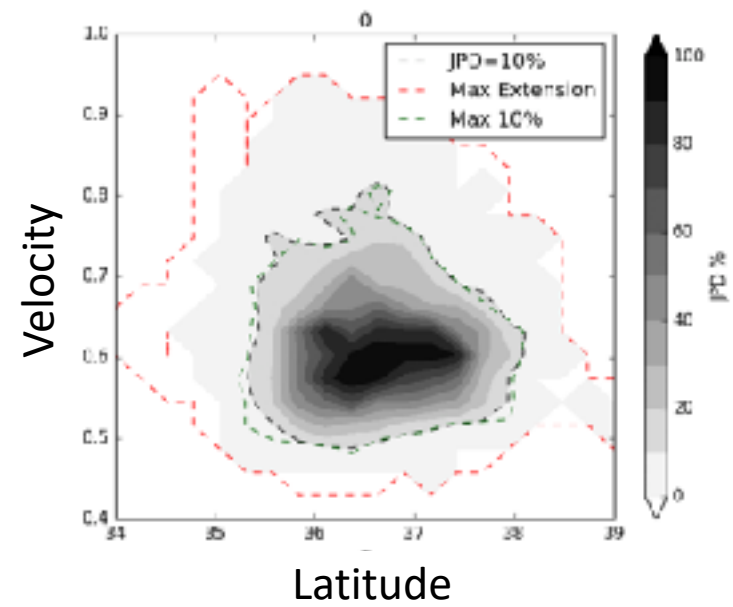
OCCITENS



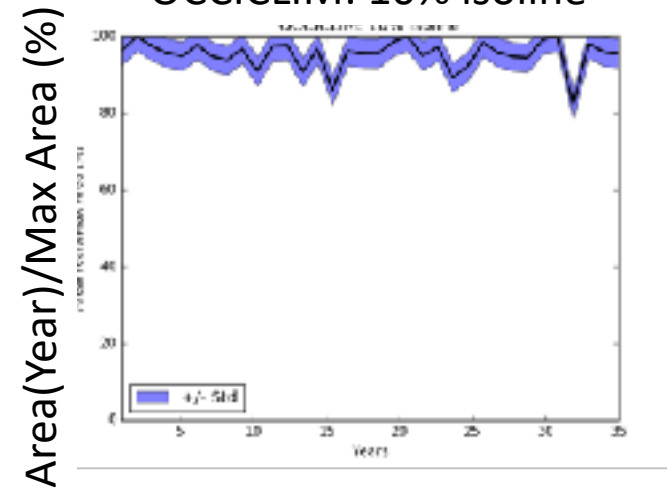
OCCITENS: 10% isoline



OCCICLIM



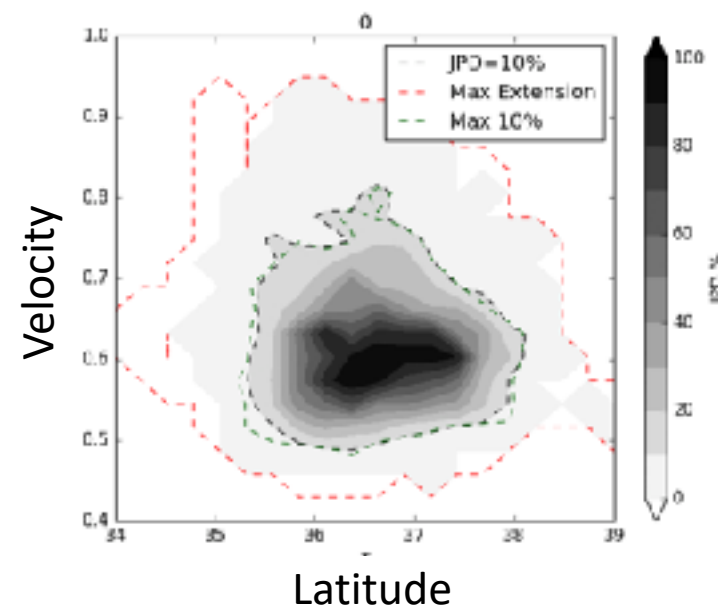
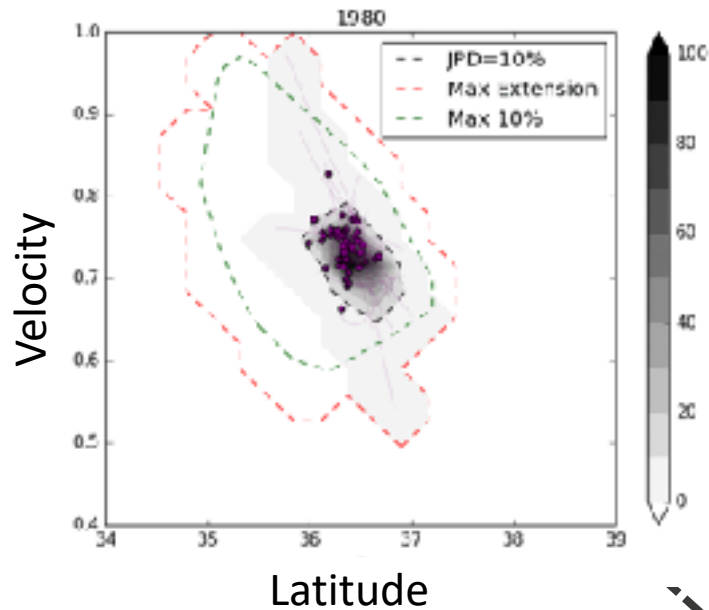
OCCICLIM: 10% isoline



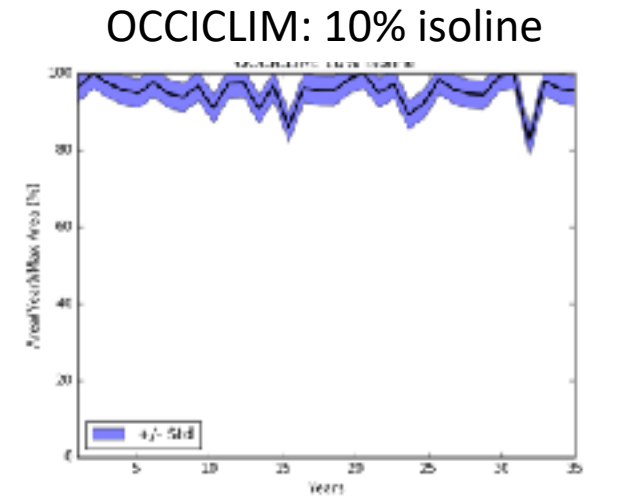
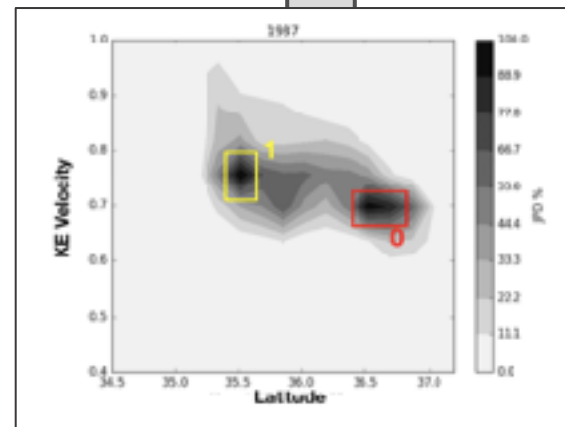
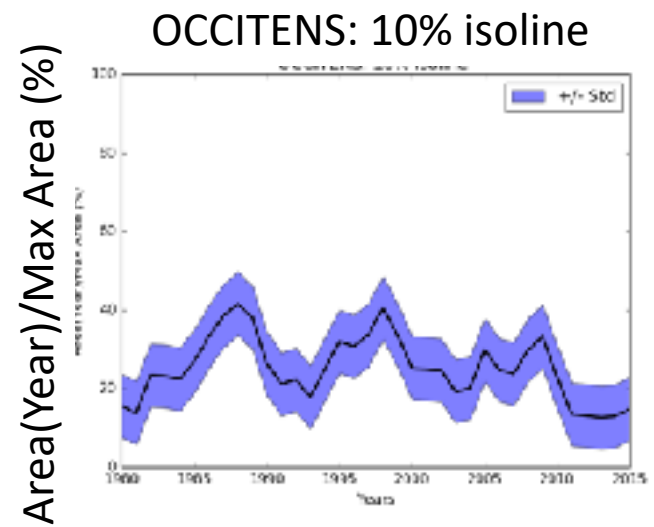
Φ, Ψ : Latitude and Velocity Indices. Changing the Y-axis variable we always get the same footprint of the attractor.

OCCITENS

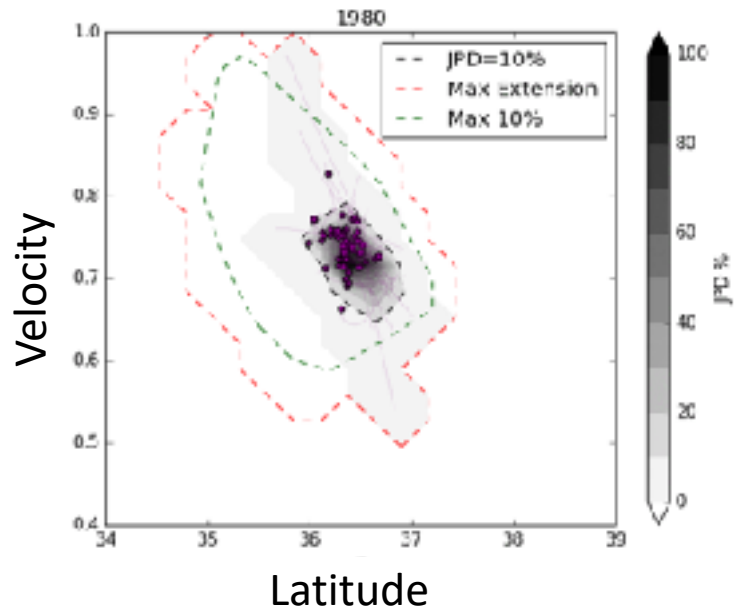
OCCICLIM



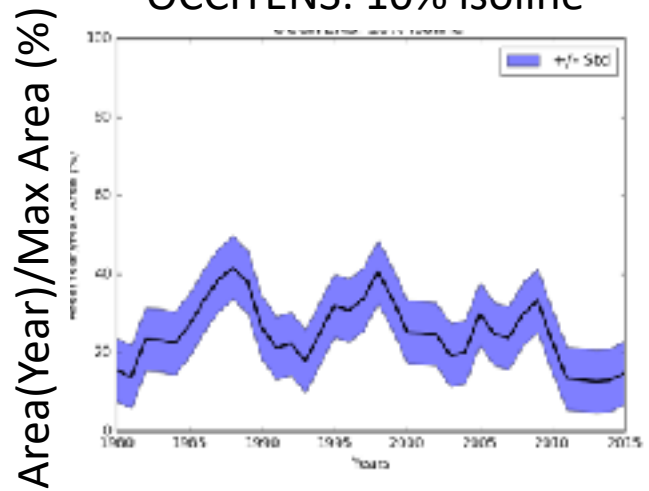
TWO MODES



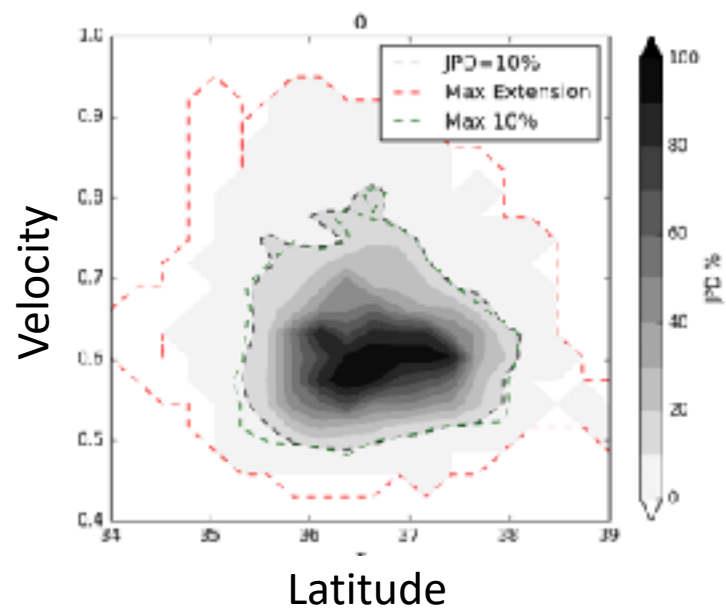
OCCITENS



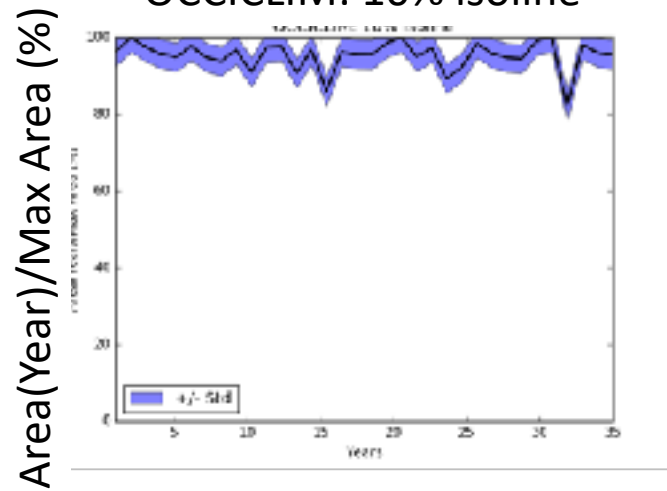
OCCITENS: 10% isoline



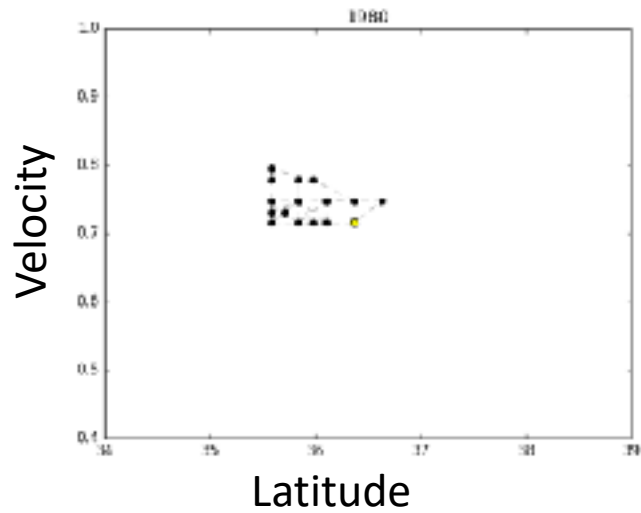
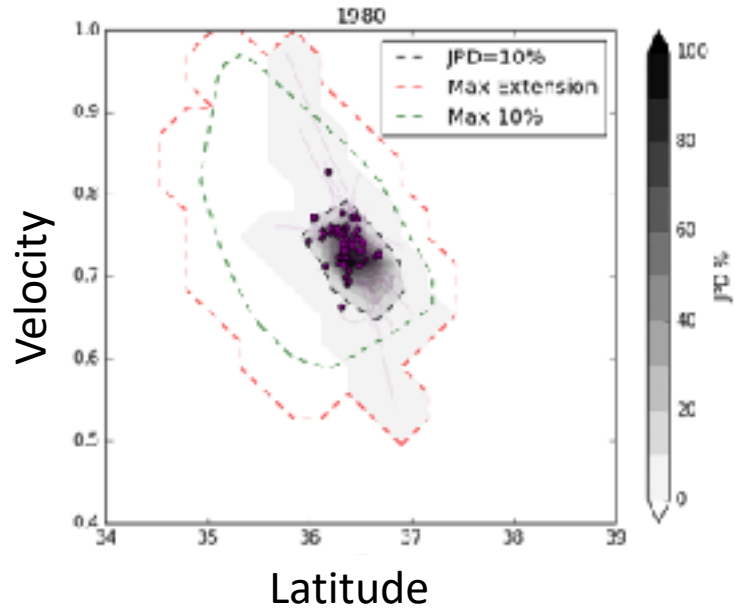
OCCICLIM



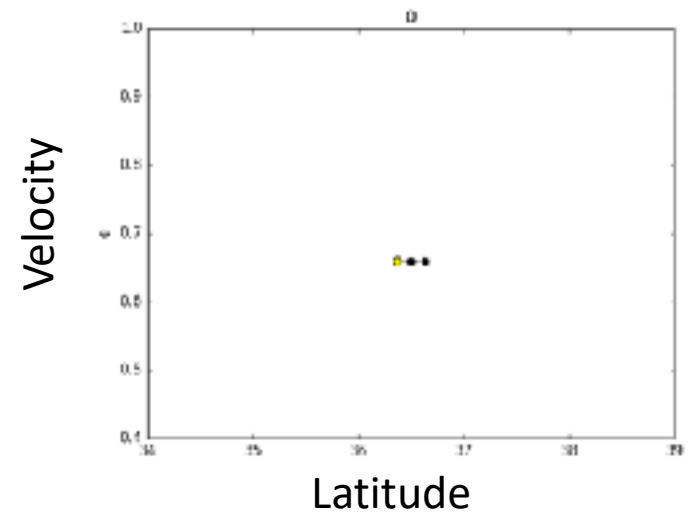
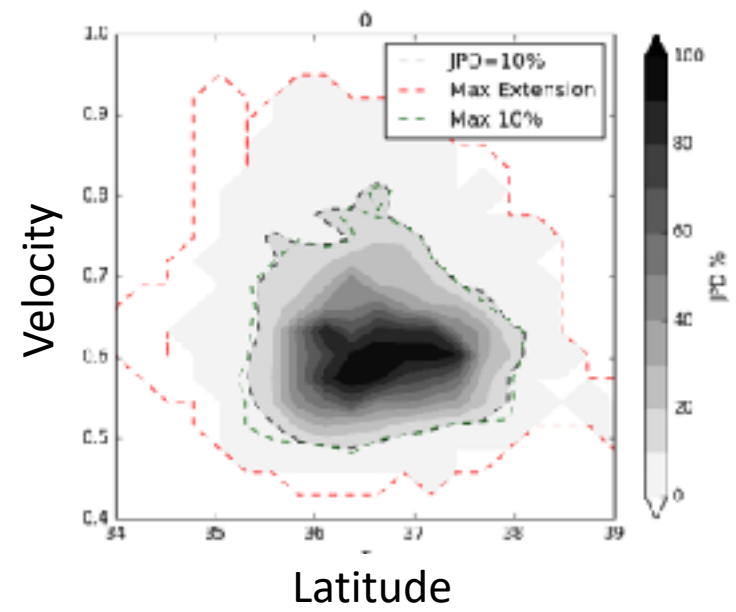
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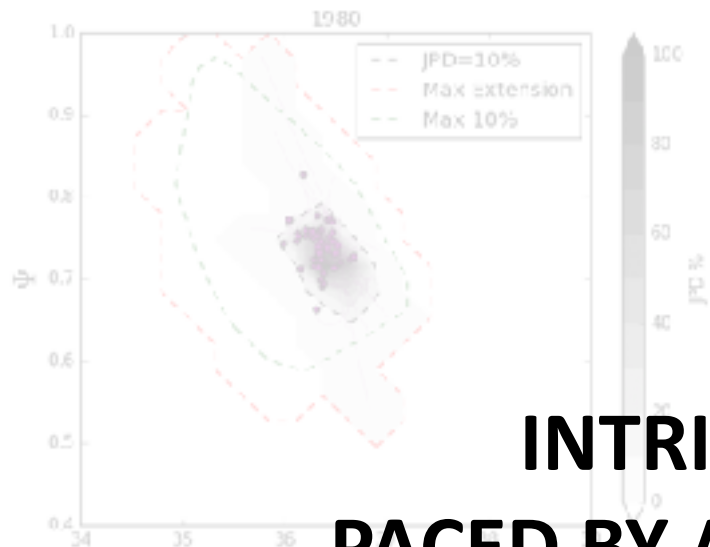
OCCITENS



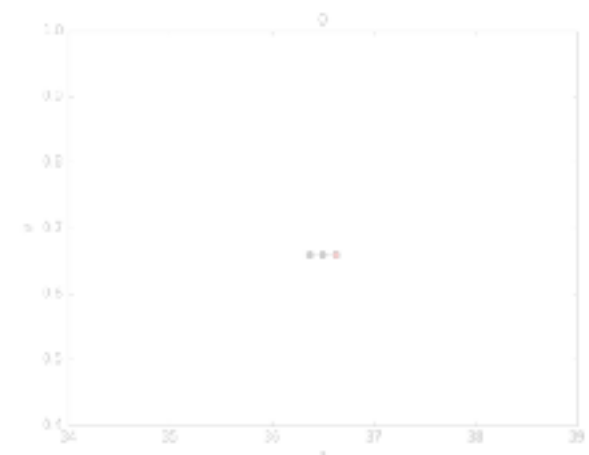
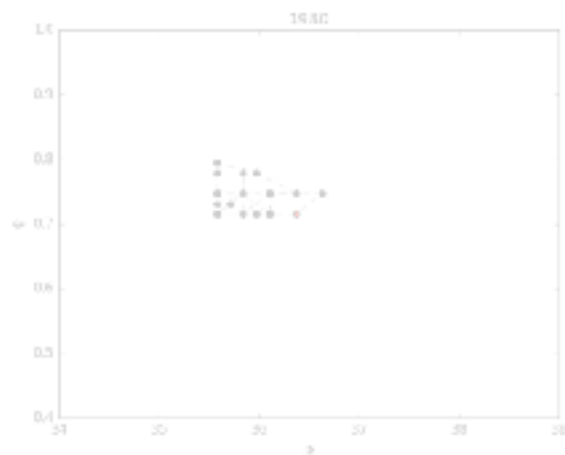
OCCICLIM

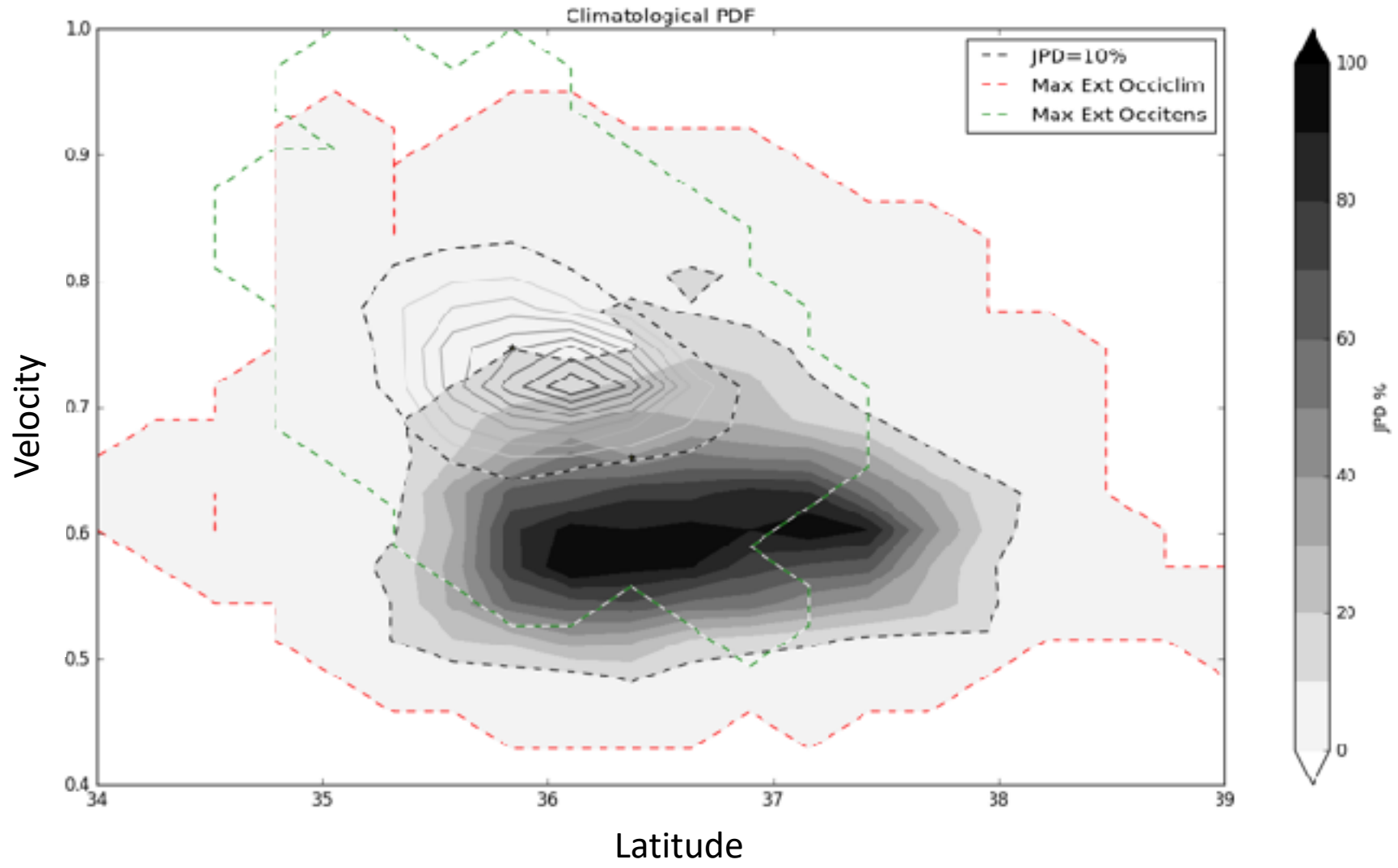


Center of Gravity



INTRINSIC VARIABILITY PACED BY AN EXTERNAL FORCING





The external forcing acts reducing the entropy of the dynamical system

CONCLUSIONS

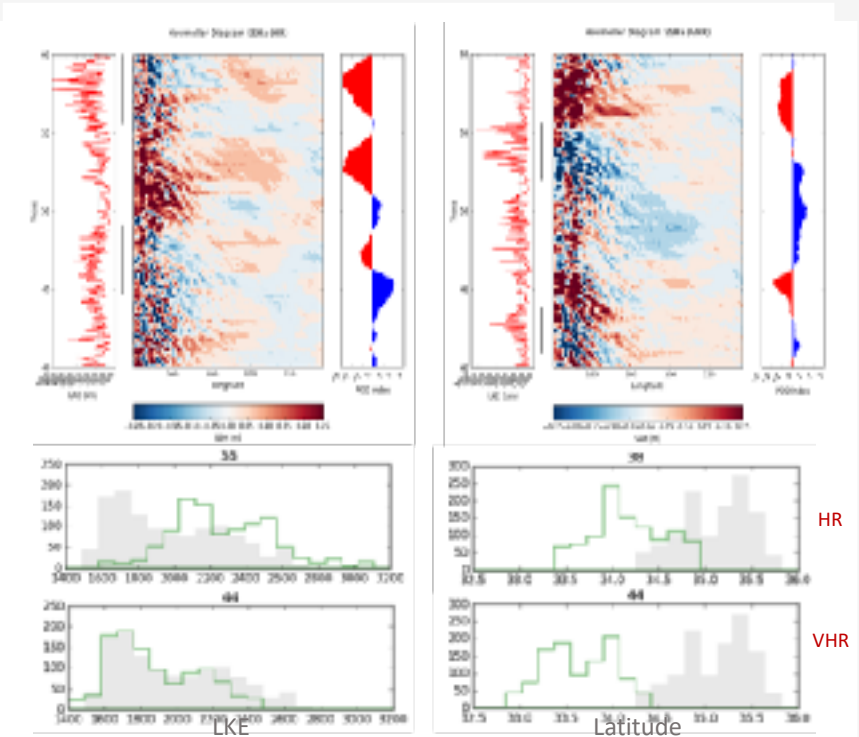
- OCCIPUT ensemble simulation : disentangle the intrinsic and forced variabilities
- The KE LFV is a case of intrinsic variability paced by an external forcing
- The external forcing acts reducing the entropy of the dynamical system

WORK IN PROGRESS

What is the ability of state of the art models in reproducing the observed KE LfV: the role of horizontal resolution -PRIMAVERA project- Model data from **HIGHRESMIP-CMIP6**

HighResMIP -CMIP6	Coupled Model	Configuration	Resolution	Forcing	Output Frequency	Vertical Levels	
OCEAN ATMOSPHERE	NEMO v3.6 CAM 4	CMCC-CM2-HR4**	0.25° 1°	Control-1950	Daily (100 yrs)	50	HR
OCEAN ATMOSPHERE	NEMO v3.6 CAM 4	CMCC-CM2-VHR4**	0.25° 0.25°	Control-1950	Daily (100 yrs)	50	VHR

** Model data are from the H2020 PRIMAVERA Project

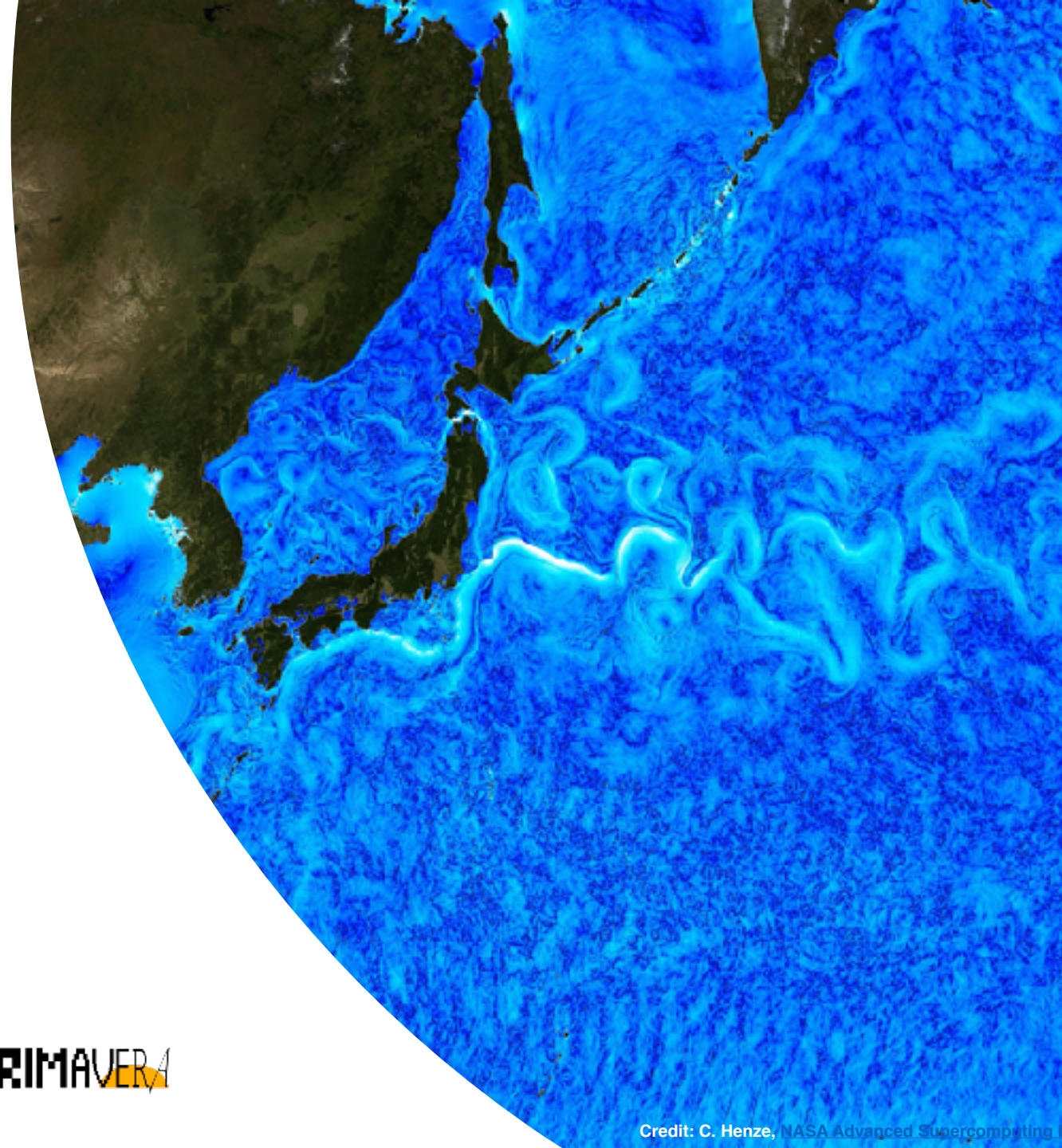


Fedele et al., in preparation



THANKS FOR YOUR ATTENTION

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