



Preliminary Inter-comparison of AIS Data and Optimal Ship Tracks

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THE BEST PRESENTATION AWARD



IN RECOGNITION OF PROFESSIONAL EXCELLENCE, THE PAPER TITLED
Preliminary Inter-Comparison of AIS Data and Optimal Ship Tracks

PRESENTED AT THE
13TH NAVIGATIONAL CONFERENCE ON MARINE NAVIGATION
AND SAFETY OF SEA TRANSPORTATION
TransNav 2019

HELD IN GDYNIA, POLAND, JUNE 12-14, HAS BEEN SELECTED AS ONE OF THE BEST PAPERS OF THE CONFERENCE.
THE AUTHORS OF THIS PAPER

*Gianandrea Mannarini, Lorenzo Carelli, Dimitris Zissis,
Giannis Spiliopoulos, Konstantinos Chatzikokolakis*

ARE HEREBY CONGRATULATED AND RECOGNIZED
FOR THE EXCELLENT RESEARCH WORK REPORTED IN THE PAPER.

CHAIRMAN OF ORGANIZING COMMITTEE
PROF. ADAM WEINTRIE

JUNE 14, 2019, GDYNIA, POLAND



Outline

- Motivations
- Methodology/Results
- Conclusions

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Motivations

Research question

"Is maritime traffic optimized? to what extent?"



MEPC 72/17/Add.1
Annex 11, page 1

ANNEX 11

RESOLUTION MEPC.304(72)
(adopted on 13 April 2018)

INITIAL IMO STRATEGY ON REDUCTION OF GHG EMISSIONS FROM SHIPS

THE MARINE ENVIRONMENT PROTECTION COMMITTEE

Candidate short-term measures

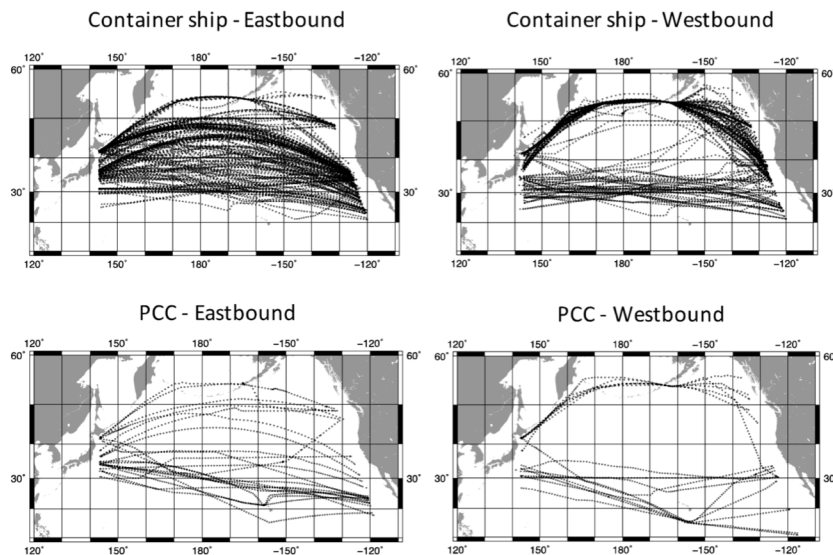
4.7 Measures can be categorized as those the effect of which is to directly reduce GHG emissions from ships and those which support action to reduce GHG emissions from ships. All the following candidate measures⁴ represent possible short-term further action of the Organization on matters related to the reduction of GHG emissions from ships:

- .1 further improvement of the existing energy efficiency framework with a focus on EEDI and SEEMP, taking into account the outcome of the review of EEDI regulations;
- .2 develop technical and operational **energy efficiency measures** for both new and existing ships, including consideration of indicators in line with the three-step approach that can be utilized to indicate and enhance the energy efficiency performance of shipping, e.g. Annual Efficiency Ratio (AER), Energy Efficiency per Service Hour (EESH), Individual Ship Performance Indicator (ISPI) and Fuel Oil Reduction Strategy (FORS);

Motivations

Research question

“Is maritime traffic optimized? to what extent?”



Shipmasters:

«minimum *distance* and least ship *motion* considering the location of *low-pressure* areas»

future work: «to propose an *algorithm* that represents the route decision/selection by shipmasters»



M. Fujii, H. Hashimoto, and Y. Taniguchi. Analysis of satellite ais data to derive weather judging criteria for voyage route selection. TransNav: International Journal on Marine Navigation and Safety of Sea Transportation, 11, 2017.

Motivations

(VISIR is open source software)



Research question..

"Is maritime traffic optimized? to what extent?"

 www.visir-model.net

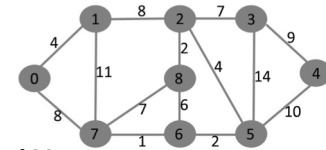
Objective:

least-time routes



Method:

Graph-search with dynamic weights



Environmental fields:

currents



waves

Verification:

1- Analytical solutions

2 – Other model



Massachusetts
Institute of
Technology

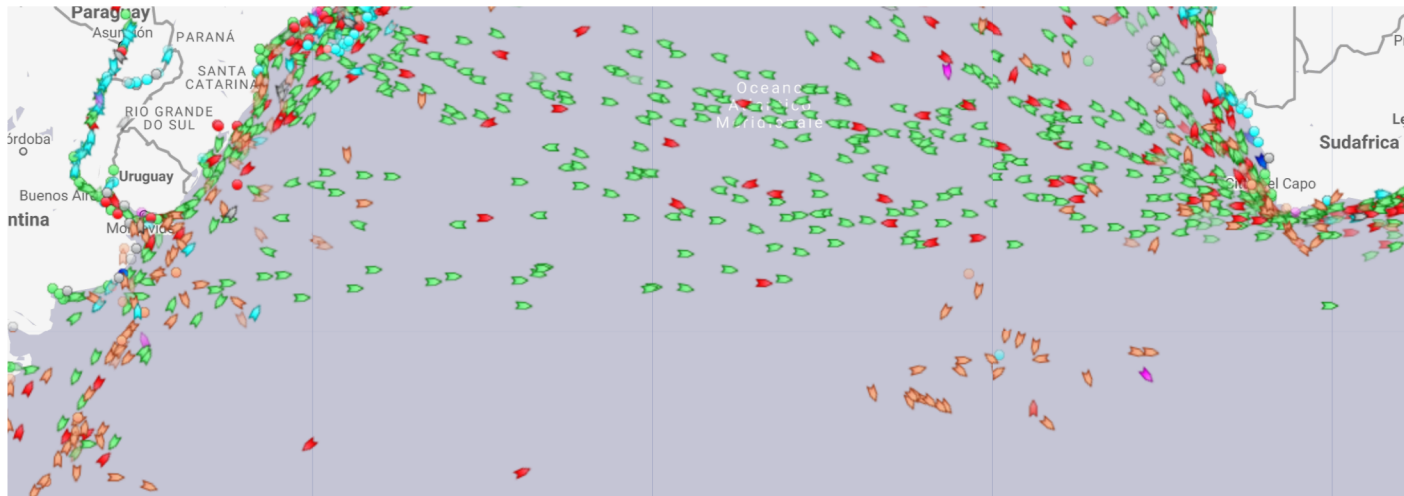
Outline

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Methodology/Results

1. Route selection criteria

- no ECA
- not significant influence of ocean currents
- no intermediate stops at islands



→ Buenos Aires (AR) - Port Elizabeth (ZA)

Methodology/Results

2. AIS datasets **filtering**



{timestamp, position, SOG, HDG, COG}



Dry bulk carriers

Length: 201(19) m
Width: 32(2) m
Power: 8600(1500) kW
Max speed: 12(2) kts

criteria	Pruning condition	Fujii 2017
Noisy tracks	zigzags	data with jumps
Speed outliers	Speed < 1 kts	Speed < 0.5 kts
Geographic region	-50 °E < longitude < +15 °E (i.e. far from harbours)	Slant limit lines

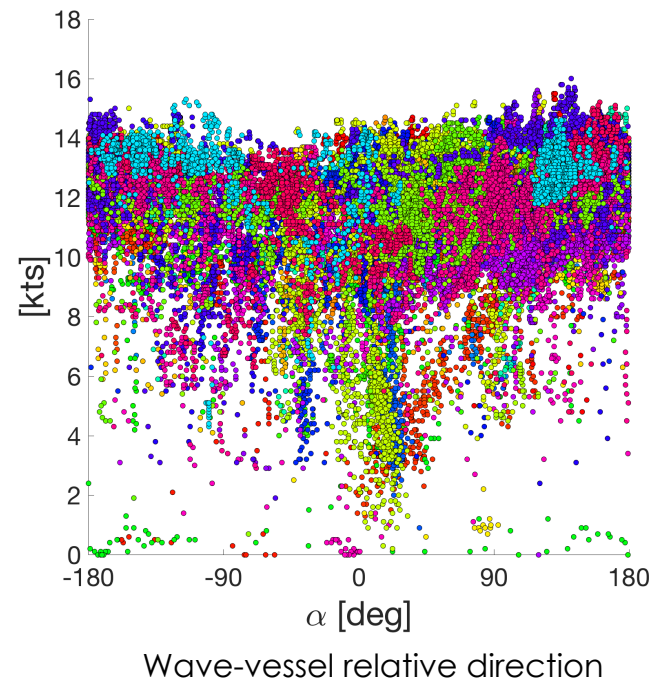
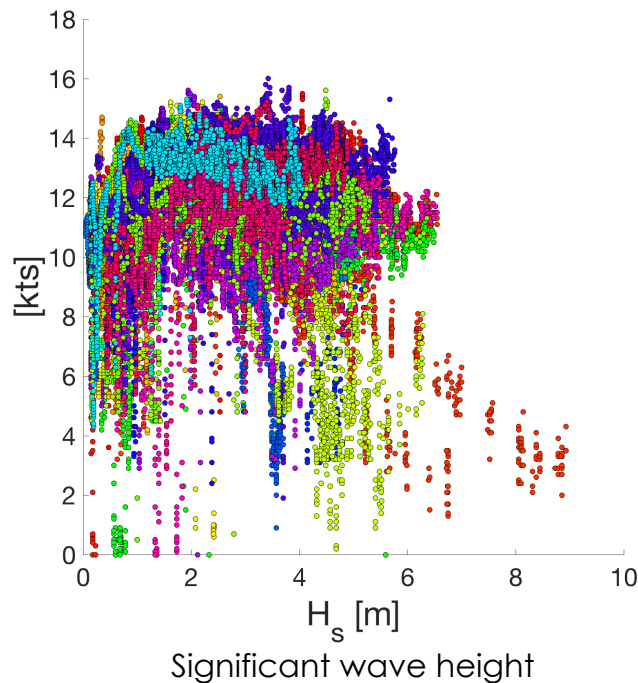
➔ 43 tracks
in 2016-2017

Methodology/Results

3. AIS **augmentation**/ “data fusion”

- H_s from space- and time- co-located 3-hourly CMEMS analysis fields;
- Use next neighbour and not interpolation (rationale: distance sailed during CMEMS time step \gg CMEMS horizontal resolution)

SOG, Eastbound voyages

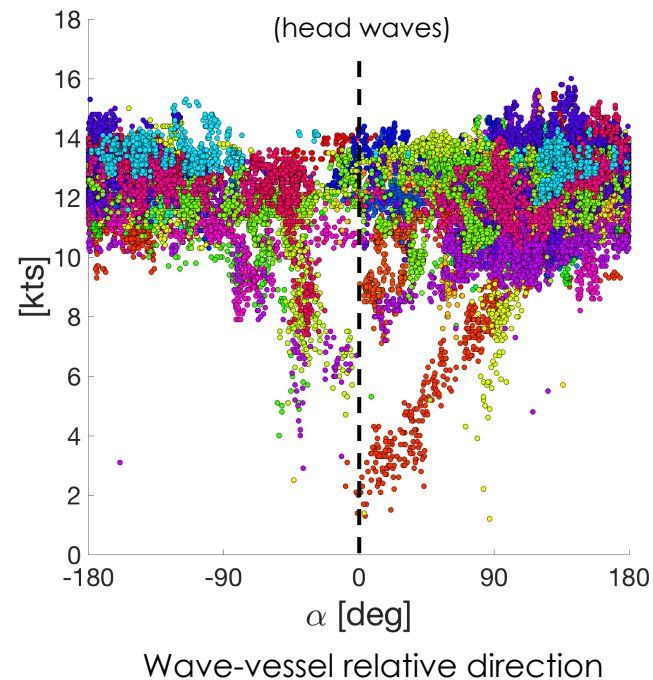
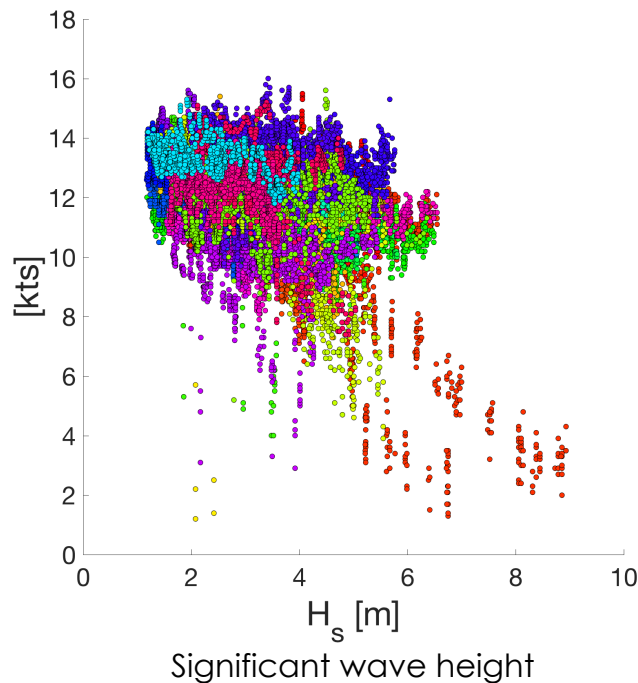


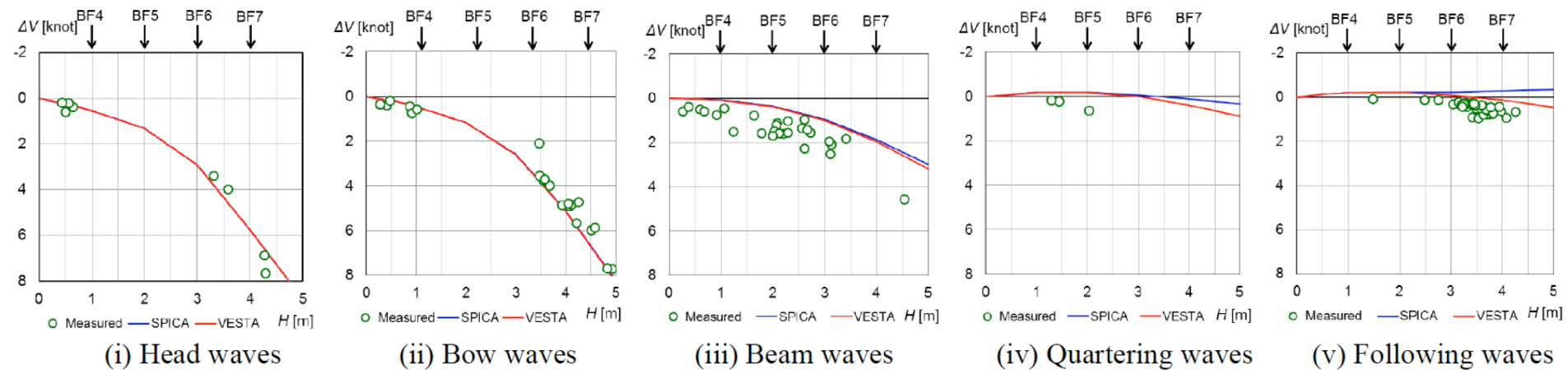
Methodology/Results

3. AIS **augmentation**/ “data fusion”

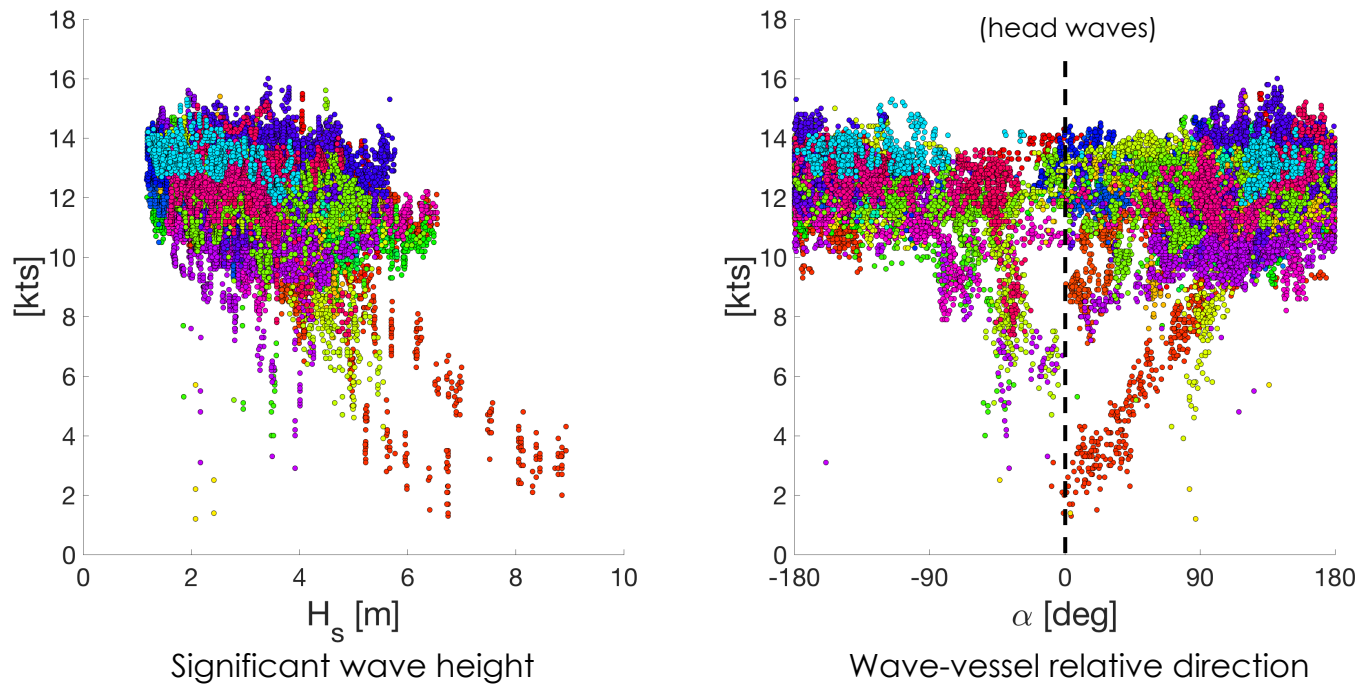
- H_s from space- and time- co-located 3-hourly CMEMS analysis fields;
- Use next neighbour and not interpolation (rationale: distance sailed during CMEMS time step \gg CMEMS horizontal resolution)

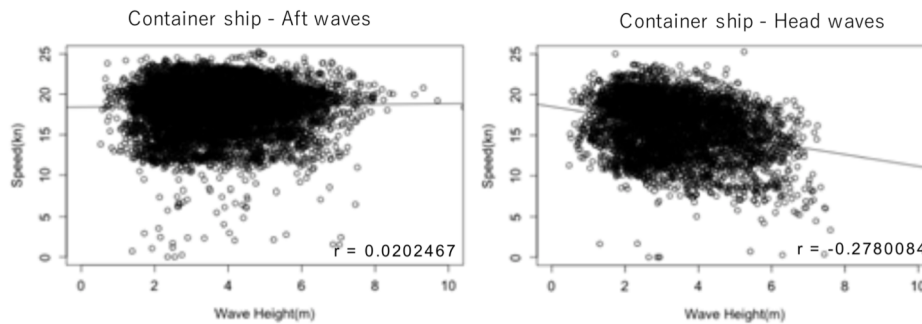
SOG, Eastbound voyages



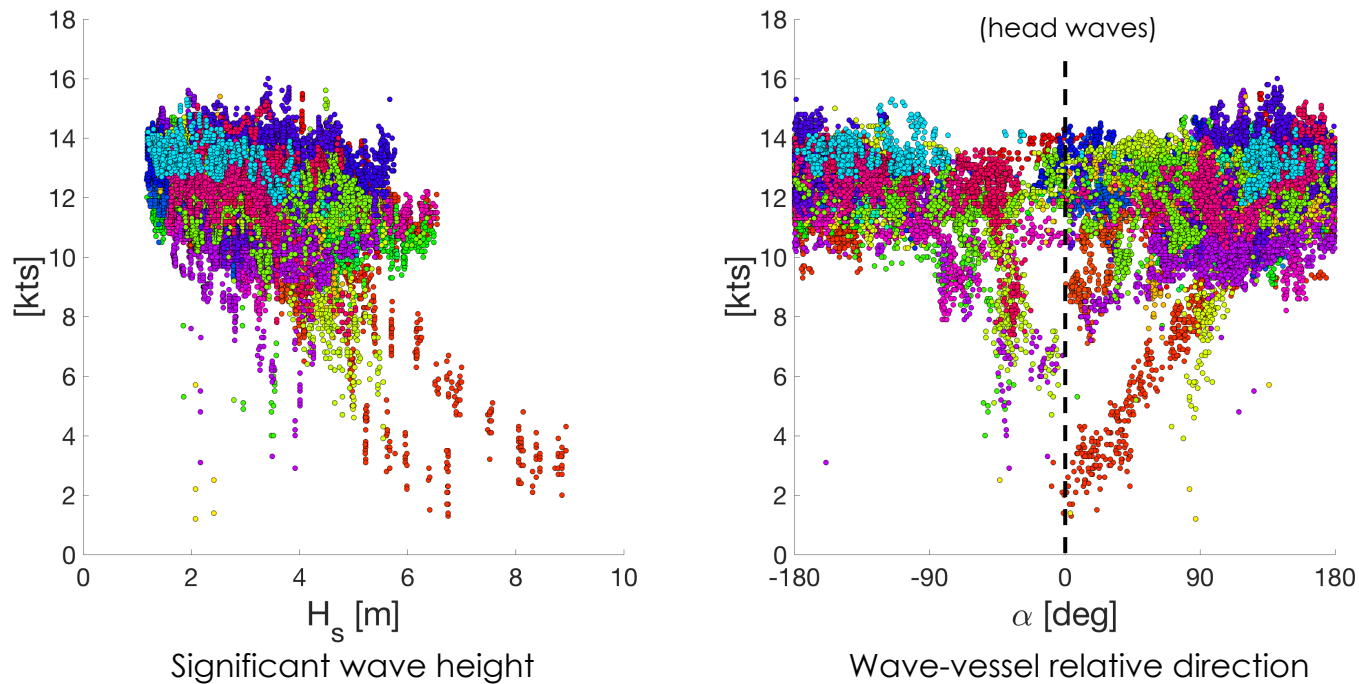


Tsujimoto, et al., 2013, in ASME 2013 32nd International Conference on Ocean, Offshore and Arctic Engineering





Fujii 2017: «Shipmasters normally avoid waves from dead ahead as much as possible»



Methodology/Results

4. identification of VISIR propulsion parameters

VISIR vessel model:

$$\eta P = -\mathbf{v} \cdot \mathbf{R}_T(P_{\max}, V_{\max}; v, H_s)$$

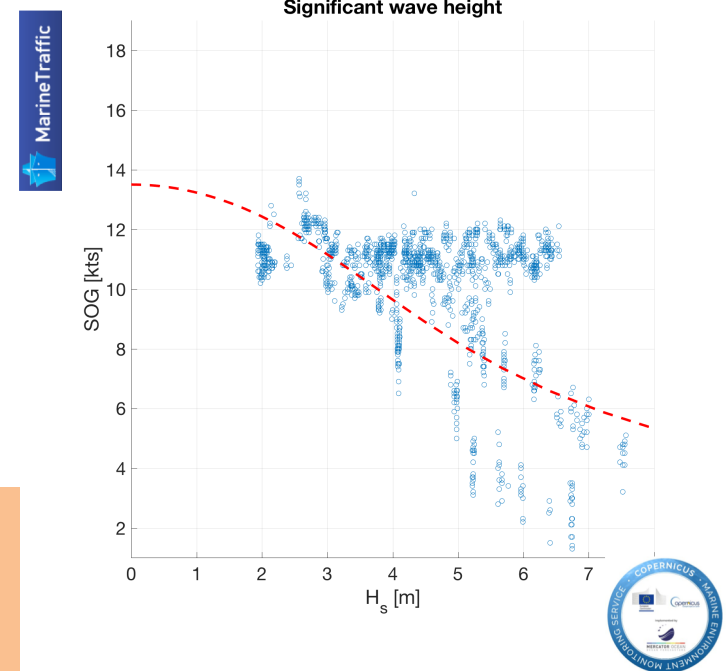
$$R_T = R_c + R_{aw}$$

R_c : constant drag coefficient

R_{aw} : peak value of radiation component

solved for: $v = v(H_s)$

(wave direction neglected)



Fitting function is
VISIR response
model with manually
fitted V_{\max} and P_{\max}
parameters

Methodology/Results

Vessel ID: **009**

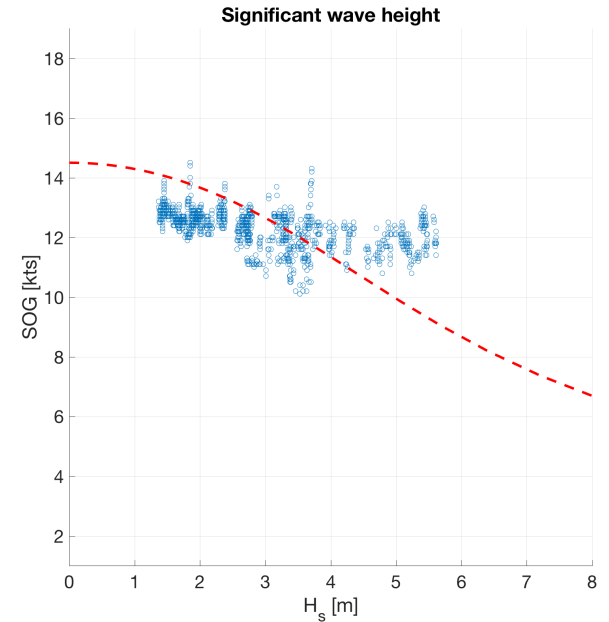
5. VISIR track computations

$$V_{\max} = 14.5 \text{ kts}$$
$$P_{\max} = 12\,700 \text{ kW}$$

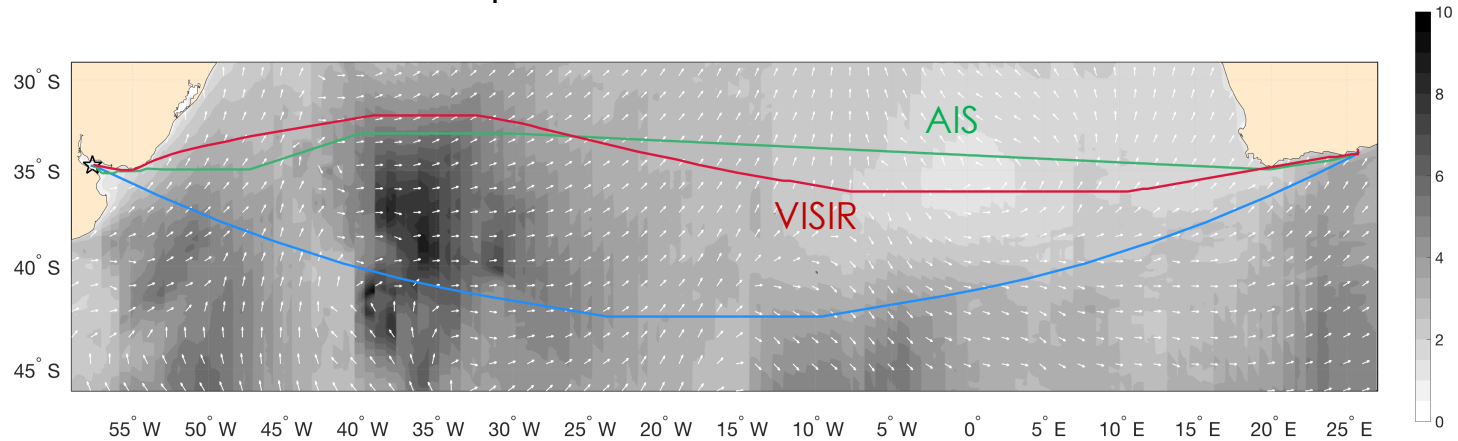
$$T_v = 327 \text{ hr}$$

$$T_a = 342 \text{ hr}$$

$$T_g = 341 \text{ hr}$$



Departure: 2017 Mar 10



Vessel ID: **002**

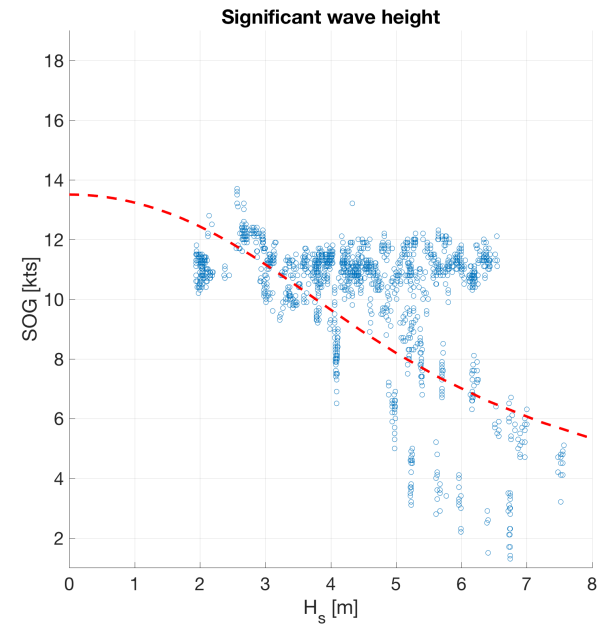
(AIS: waves encountered late)

$V_{\max} = 13.5$ kts
 $P_{\max} = 8\,400$ kW

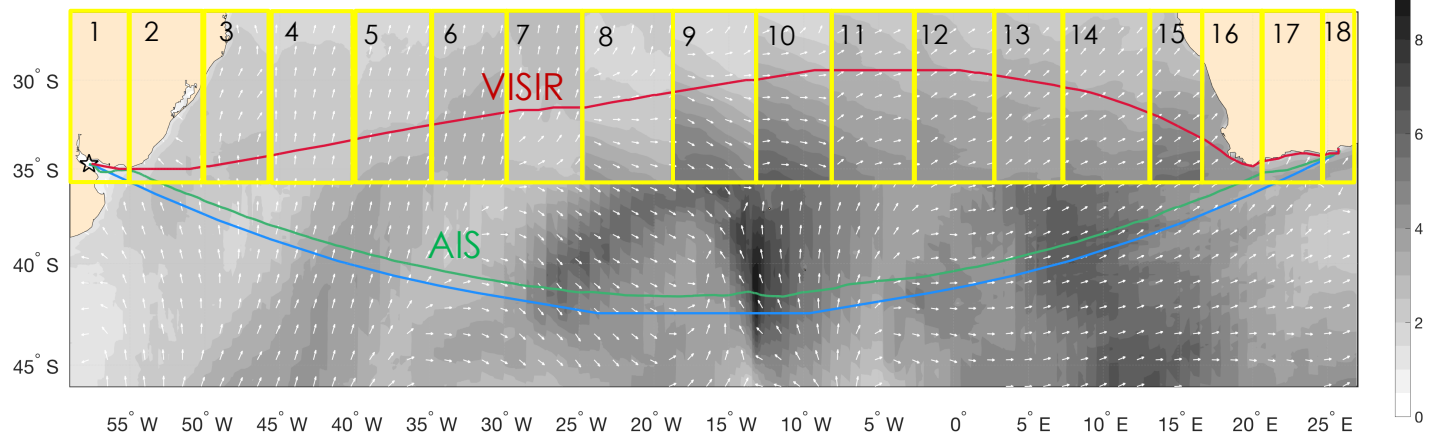
$T_v = 380$ hr

$T_a = 402$ hr

$T_g = 422$ hr



Departure: 2016 Jul 31



Vessel ID: **051**

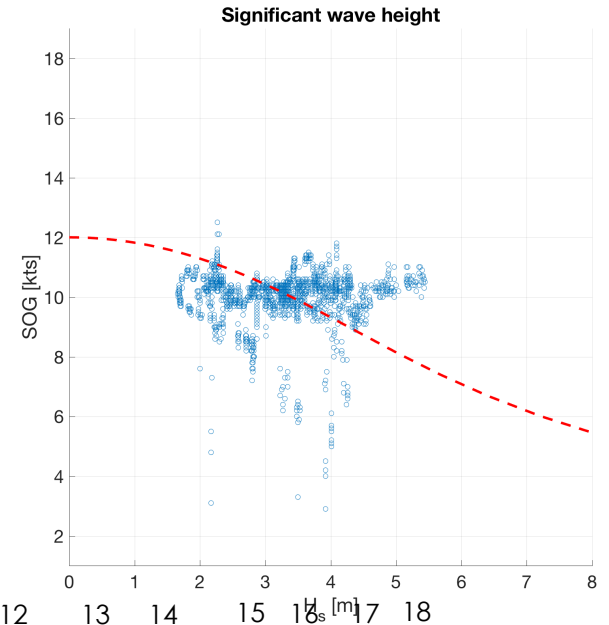
(VISIR: daily-averaged too different from
3-hourly waves)

$V_{\max} = 12.0$ kts
 $P_{\max} = 8\,700$ kW

$T_v = 391$ hr

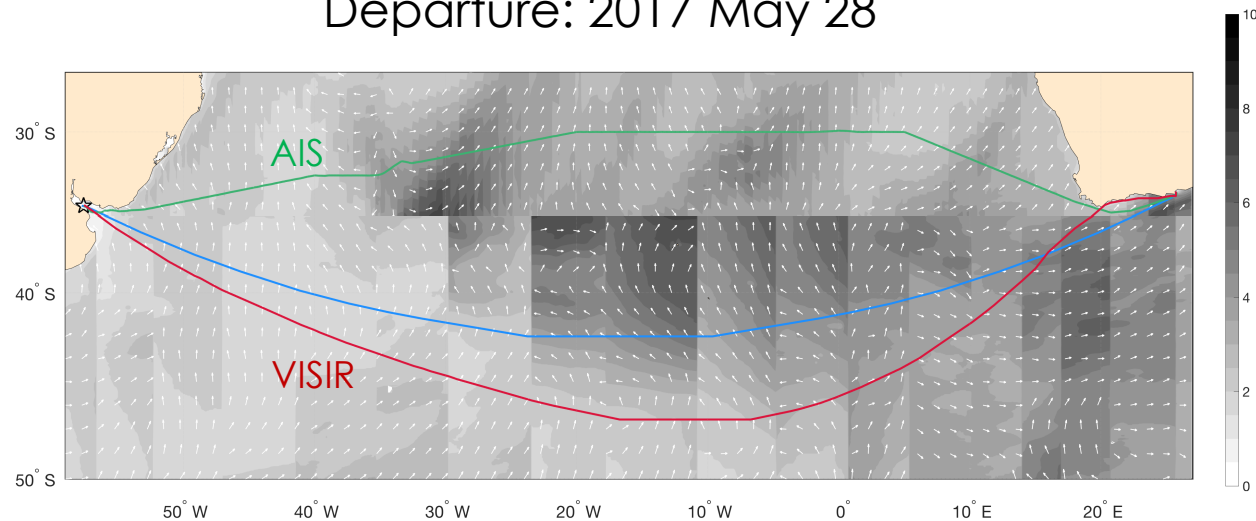
$T_a = 447$ hr

$T_g = 406$ hr



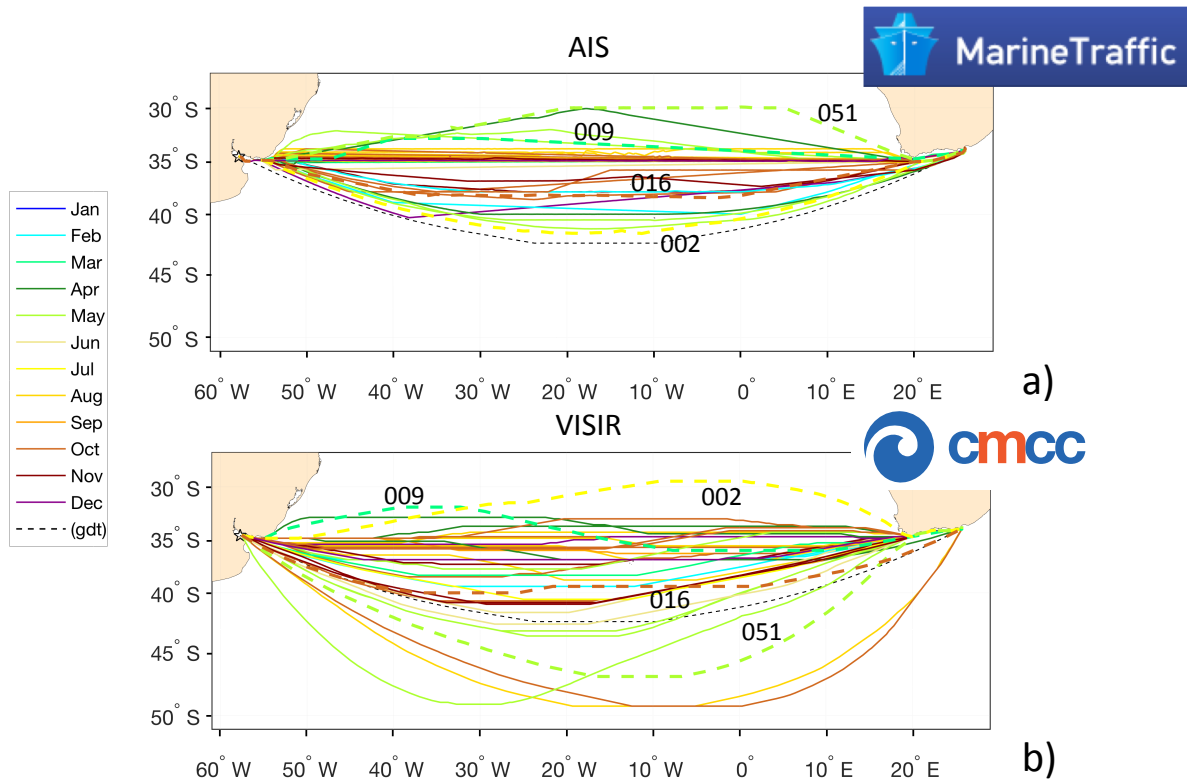
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Departure: 2017 May 28



Methodology/Results

6. Statistical analysis of track geometry



Bundle meridional extent:

- AIS: 12 deg
- VISIR: 20 deg

Larger diversions during (Southern) autumn months

Some VISIR tracks even South of the geodetic

Methodology/Results

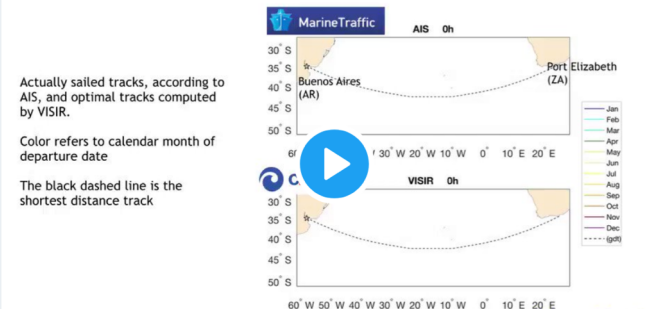
6. Statistical analysis of track geometry



GM
@gianandream

Preview of today's VISIR presentation at [#TransNav2019](#) (session B4 at 12:00 in Auditorium Max): in the movie, ship tracks in the Southern Atlantic ocean from AIS data and optimal path computations by VISIR ([visir-model.net](#)). We are getting closer and closer! [@CmccClimate](#)

Comparison of VISIR to AIS track data



(Mannarini et al., TransNav 2019
http://www.transnav.eu/Article_Preliminary_Inter-comparison_of_49_874.html)
www.visir-model.net

0:13 39 views

7:56 AM - 13 Jun 2019

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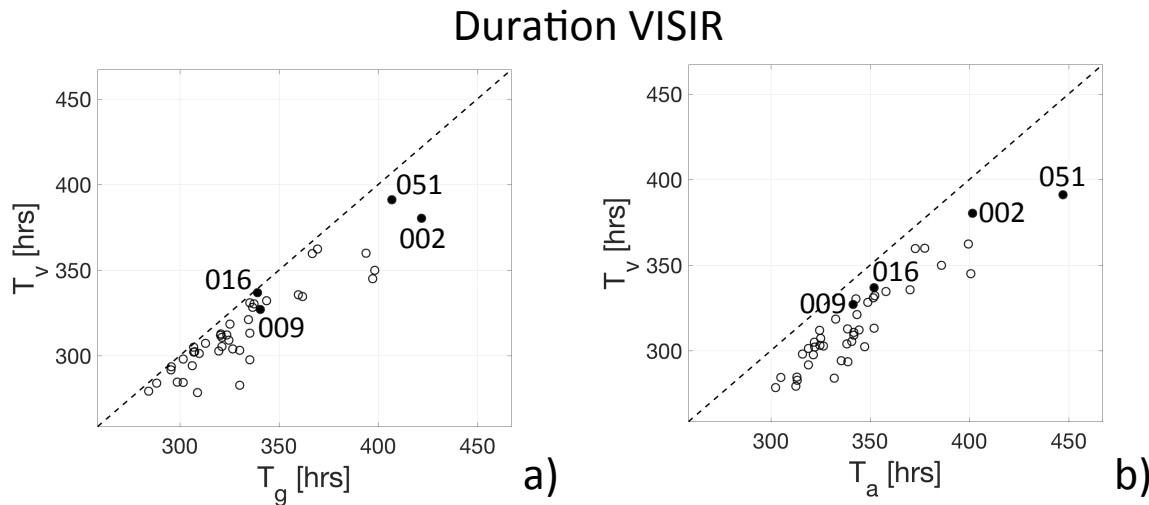
animation:

<https://zenodo.org/record/3256116>

Methodology/Results

7. Statistical analysis of track durations

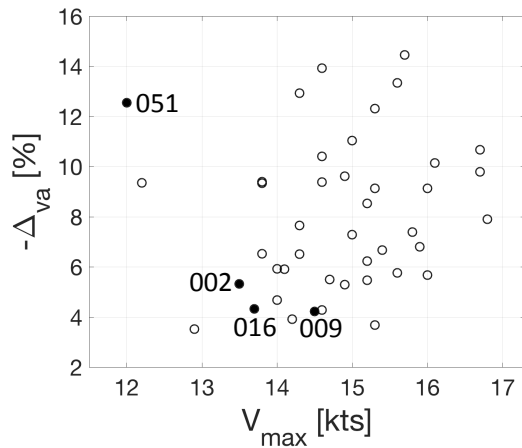
VISIR's optimal track duration always shorter than:



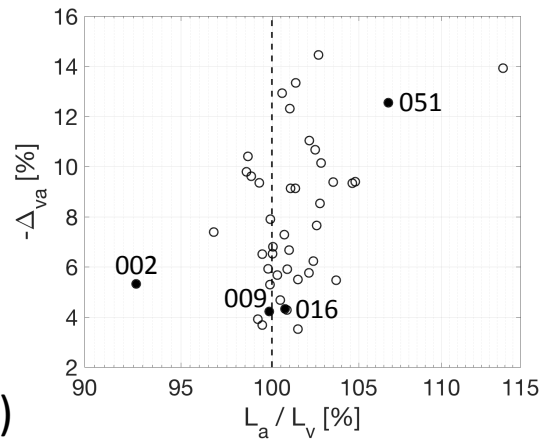
a) geodetic track duration

b) AIS duration, especially for most dissimilar tracks (002 and 051)

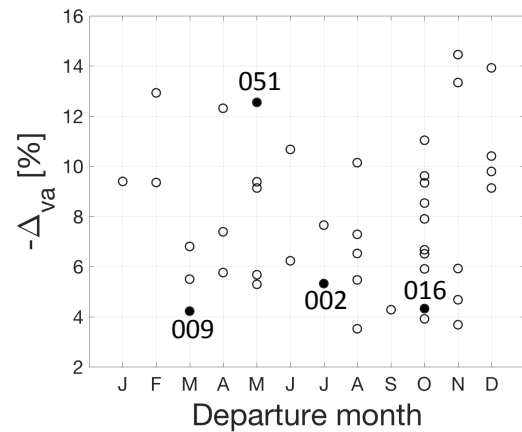
VISIR duration savings



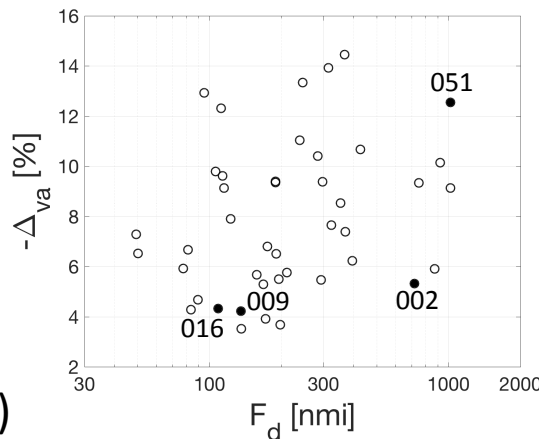
a)



b)



c)



d)

VISIR duration gains increasing:

- a) With (fitted) max vessel speed
- b) With excess AIS-tot-VISIR track length
- c) During (Southern) summer months...?
- d) With AIS-VISIR Fréchet distance

small $F_d \rightarrow L_a/L_v \sim 1$
(not viceversa)

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Conclusions

- **New** Methodology for reconstructing ship speed loss in waves through data fusion (CMEMS + AIS)
- Fair VISIR-AIS **agreement**:
 - Tracks form a bundle (seasonal variability)
 - VISIR tracks always faster
 - Larger VISIR savings for faster vessels (tbc)
- Disagreement might be due to:
 - **VISIR model** (just daily fields, no wave direction)
 - Unavailability (for the shipmaster) of long-enough wave forecasts



www.visir-model.net



VISIR References

www.visir-model.net/publications



G. Mannarini and L. Carelli. VISIR-I.b: waves and ocean currents for energy efficient navigation. *Geoscientific Model Development Discussions*, 2019, in review.



G. Mannarini, L. Carelli, D. Zisis, G. Spiliopoulos, and K. Chatzikokolakis. Preliminary inter-comparison of AIS data and optimal ship tracks. *TransNav*, 13(1):53–61, 2019.



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