TransNav2019
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on Marine Navigation and Safety of Sea
Transportation*
Gdynia (Poland)
http://transnav2019.am.gdynia.pl/

Preliminary Inter-comparison of AIS Data and Optimal Ship Tracks

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Date 13-06-2019

1 cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

2 University of the Aegean

3 MarineTraffic

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.

JUNE 14, 2019, GDYNIA, POLAND

CHAIRMAN OF ORGANIZING COMMITTEE
PROF. ADAM WEINTRIT

http://www.transnav.eu/Article_Preliminary_Inter-comparison_of_,49,874.html

Outline

- Motivations
- Methodology/Results
- Conclusions

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Motivations

Research question

"Is maritime traffic optimized? to what extent?"

INTERNATIONAL MARITIME ORGANIZATION

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 measures[4] represent possible short-term further action of the Organization on matters related to the reduction of GHG emissions from ships:

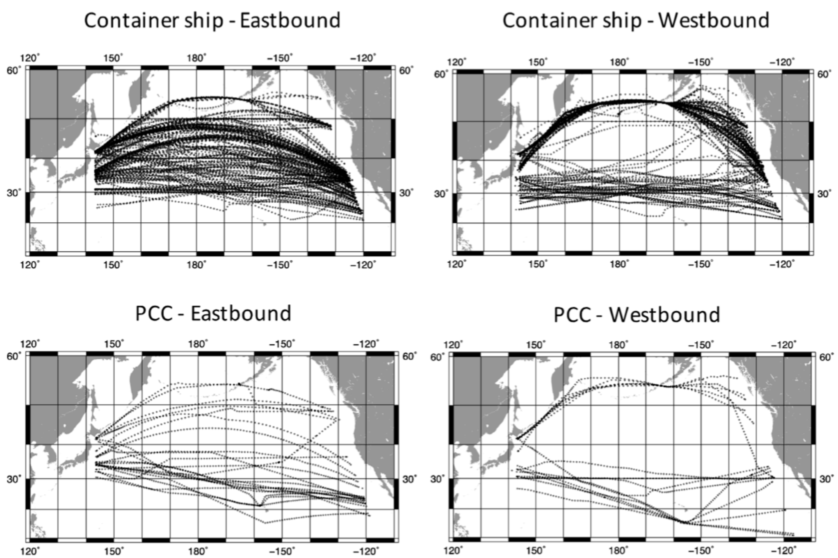
.1 further improvement of the existing energy efficiency framework with a focus on EEDI and SEEMP, taking into account the outcome of the review of EEDI regulations;

.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?"



<u>Shipmasters</u>:
«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»

TRANSNAV
INTERNATIONAL JOURNAL ON MARINE NAVIGATION AND SAFETY OF SEA TRANSPORTATION

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

Research question..

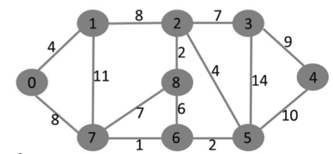
"Is maritime traffic optimized? to what extent?"

cmcc www.visir-model.net

Objective:

least-time routes

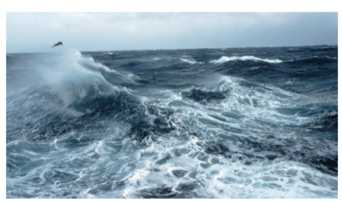
Method:



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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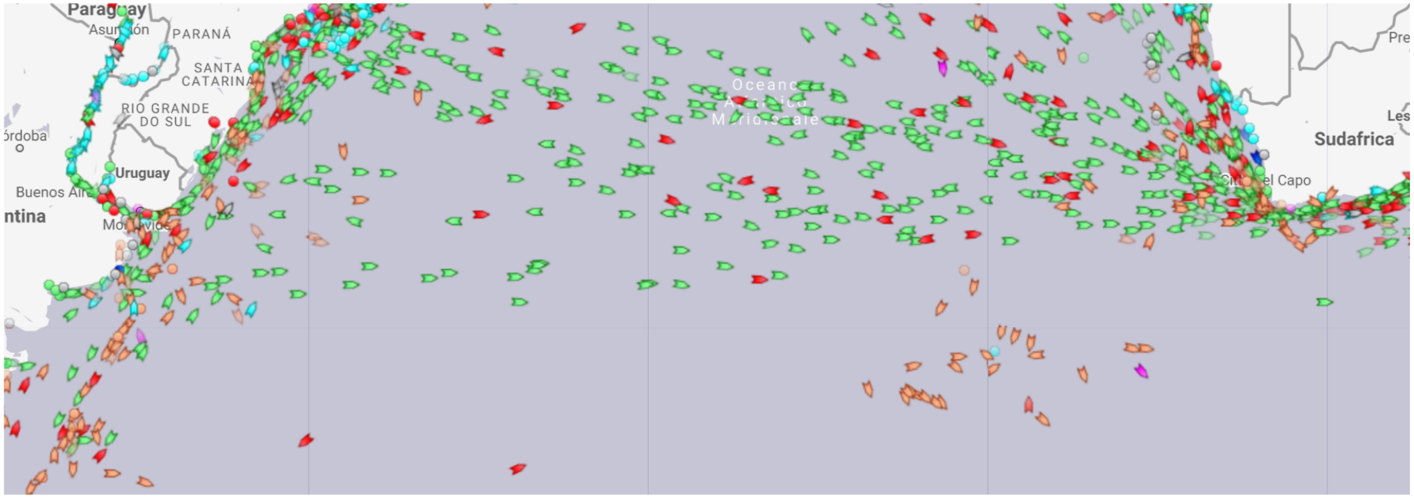
Methodology/Results

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

MarineTraffic {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

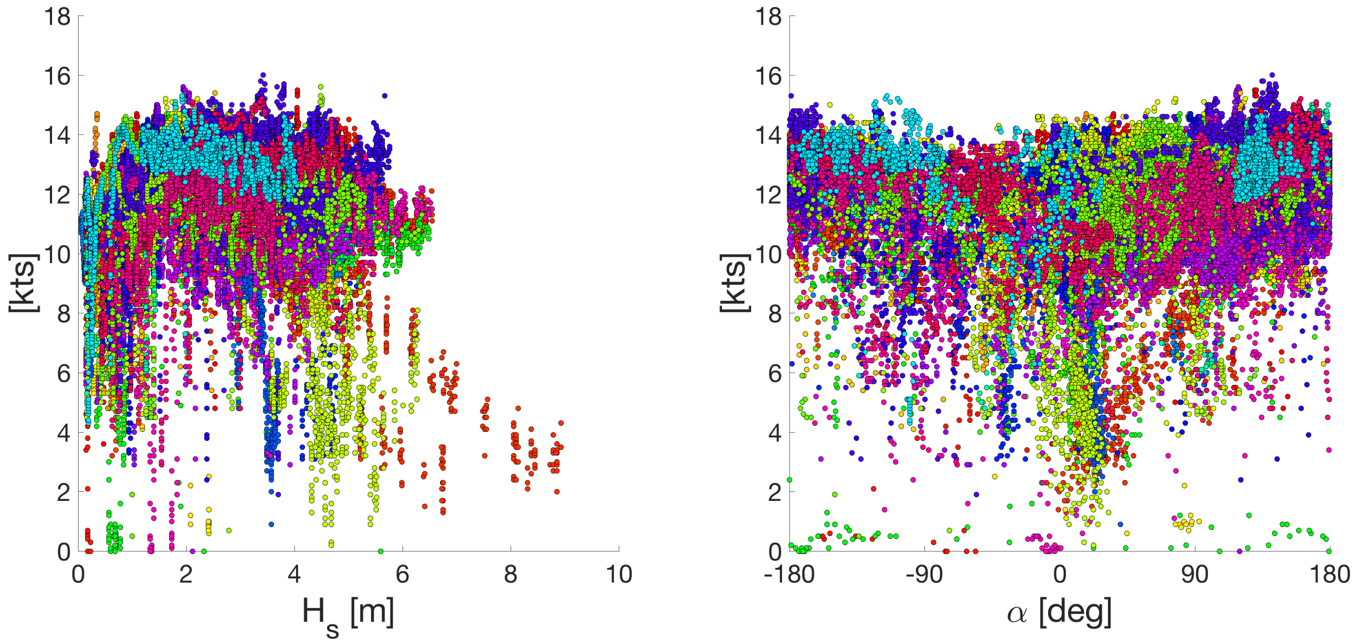
➔ 43 tracks in 2016-2017

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 >> CMEMS horizontal resolution)

SOG, Eastbound voyages



Significant wave height

Wave-vessel relative direction

Methodology/Results

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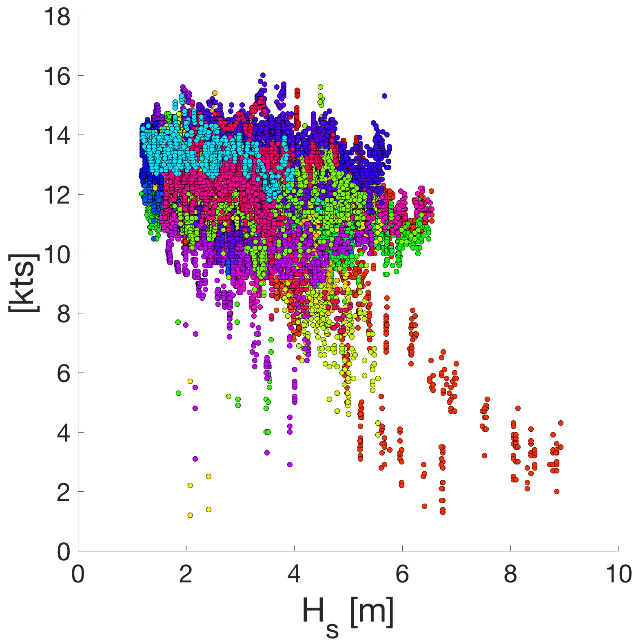
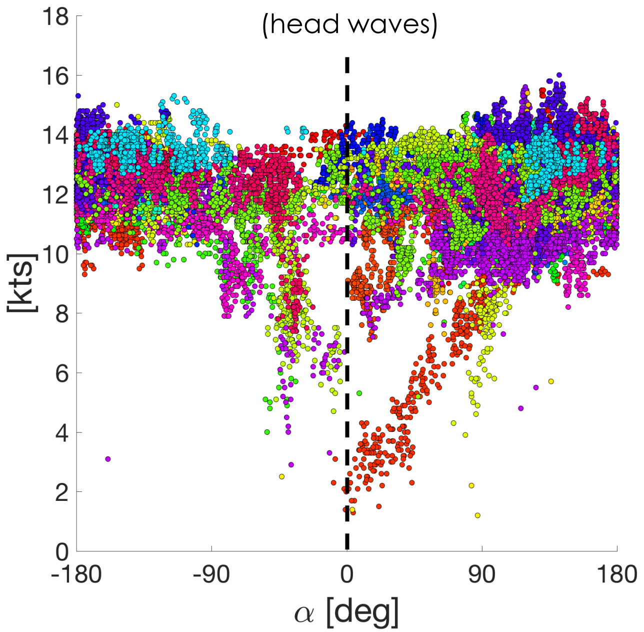
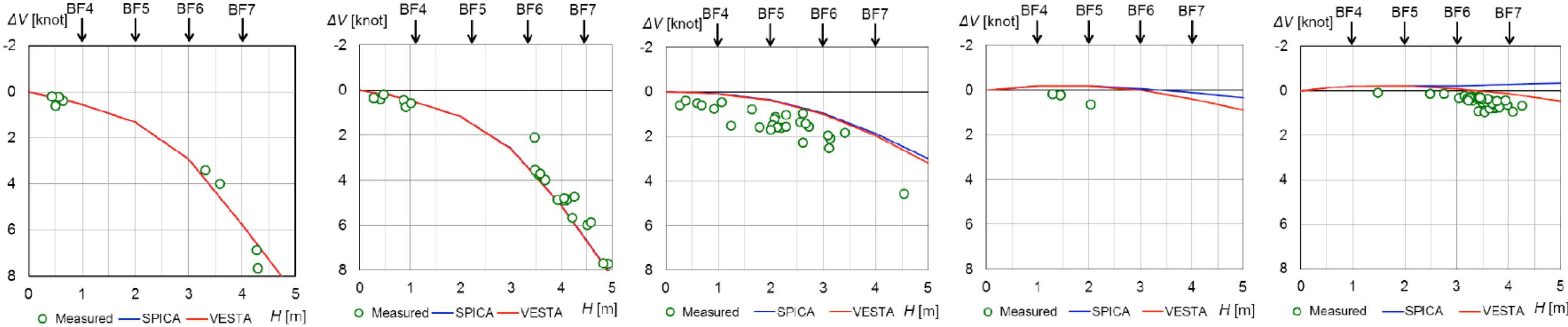


Significant wave height

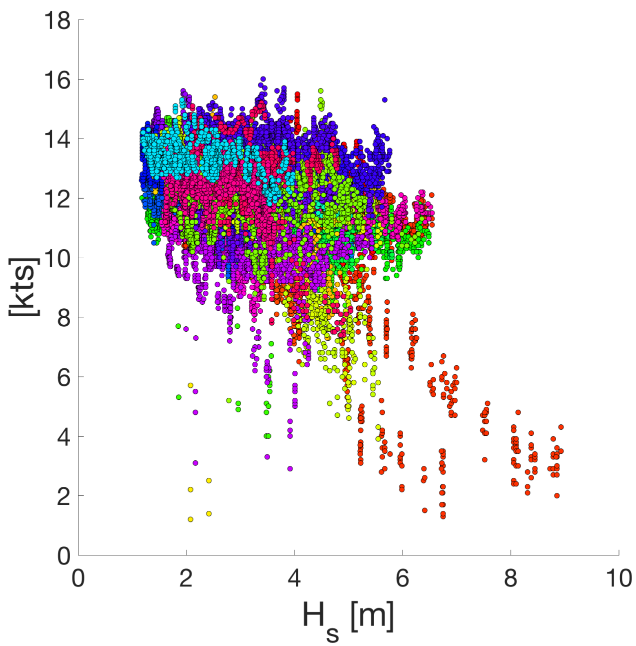


Wave-vessel relative direction

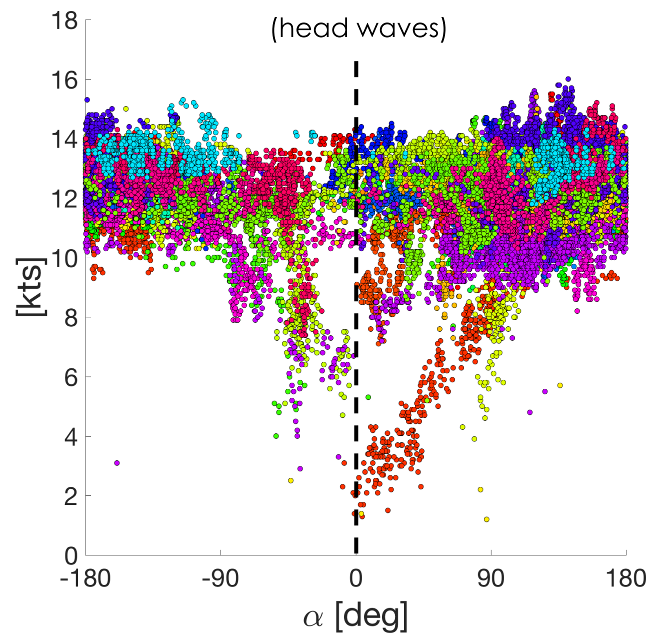


(i) Head waves (ii) Bow waves (iii) Beam waves (iv) Quartering waves (v) Following waves

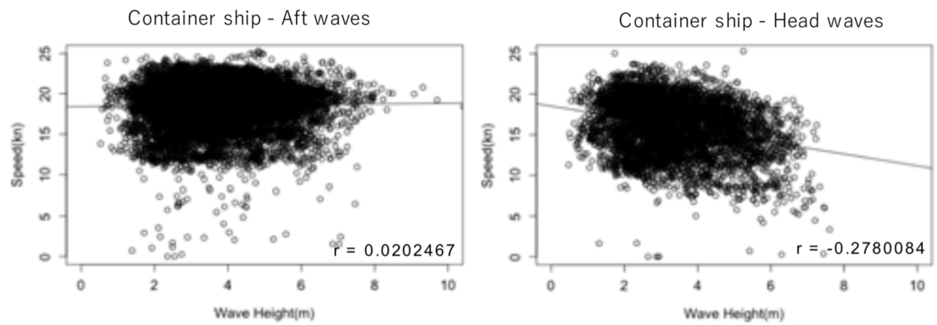
Tsujimoto, et al., 2013, in ASME 2013 32nd International Conference on Ocean, Offshore and Arctic Engineering



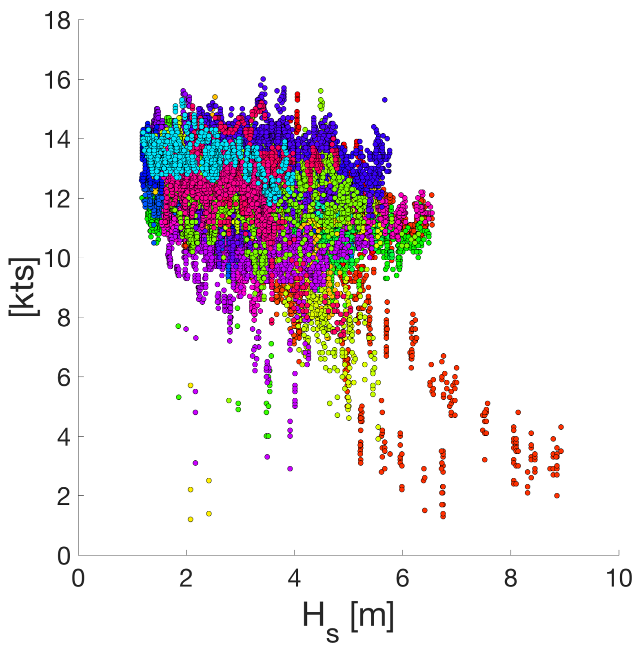
Significant wave height



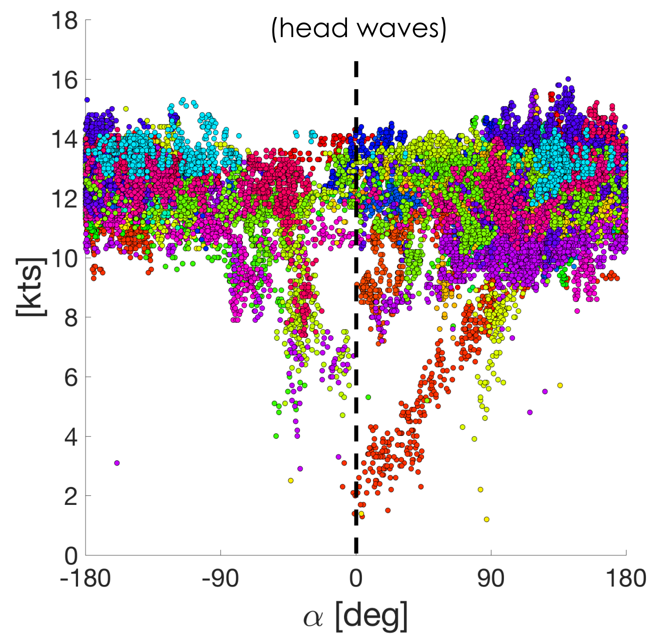
Wave-vessel relative direction



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



Significant wave height



Wave-vessel relative direction

Methodology/Results

4. identification of VISIR propulsion parameters

VISIR vessel model:

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

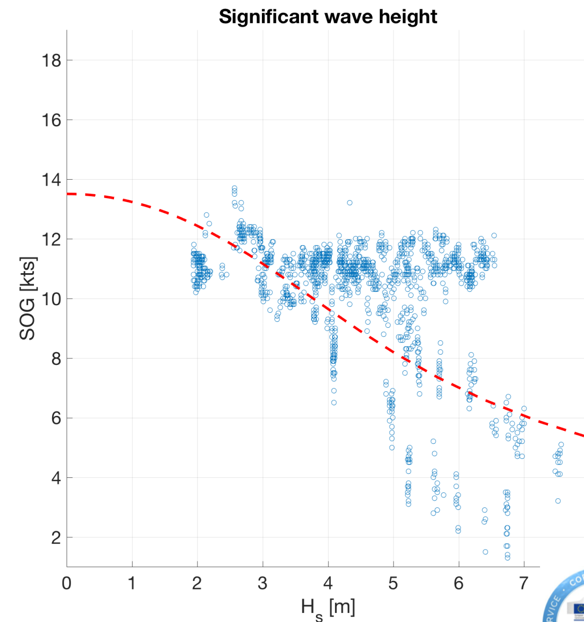
$$R_T = R_c + R_{\text{aw}}$$

R_c : constant drag coefficient

R_{aw} : peak value of radiation component

solved for: $v = v(H_s)$

(wave direction negelected)



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

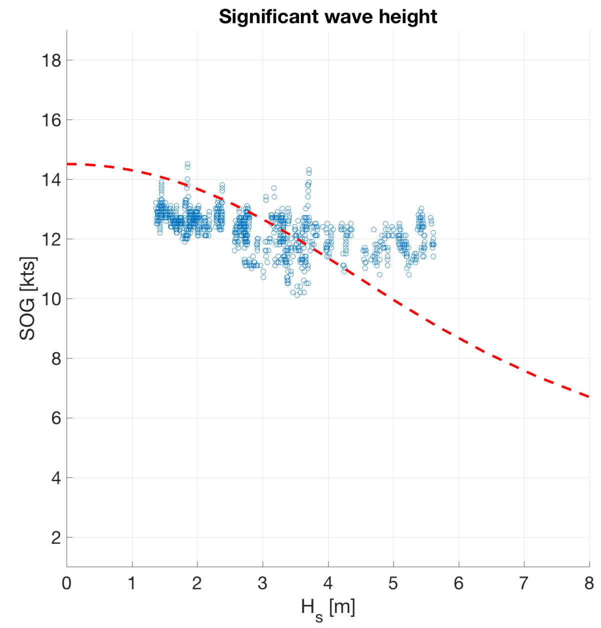
Methodology/Results

Vessel ID: **009**

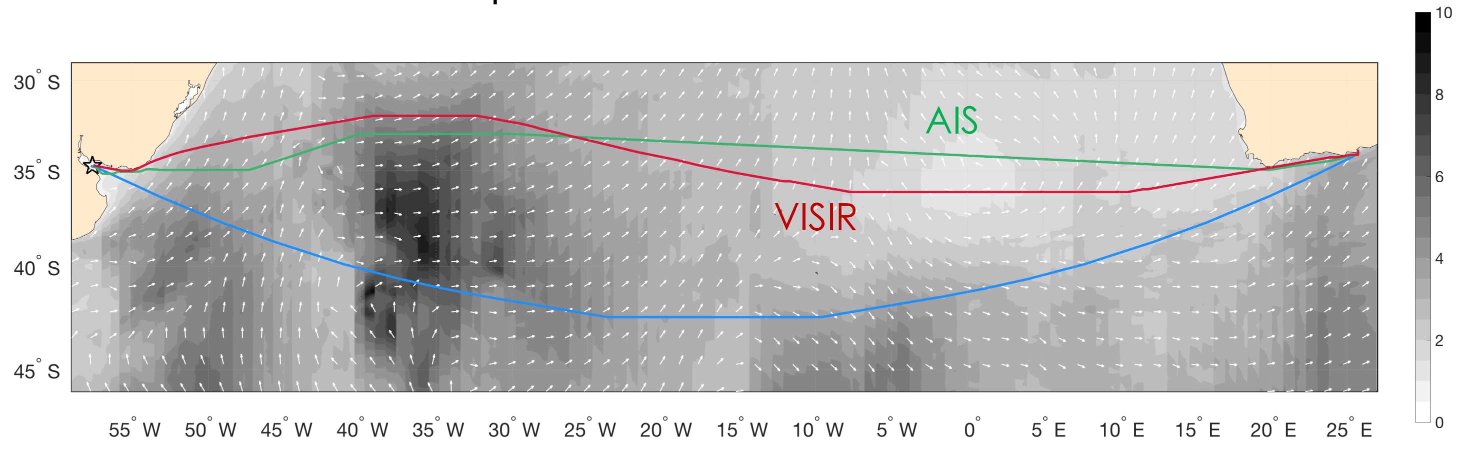
5. VISIR track computations

V_{max}= 14.5 kts
P_{max}= 12 700 kW

T_v= 327 hr
T_a= 342 hr
T_g= 341 hr



Departure: 2017 Mar 10

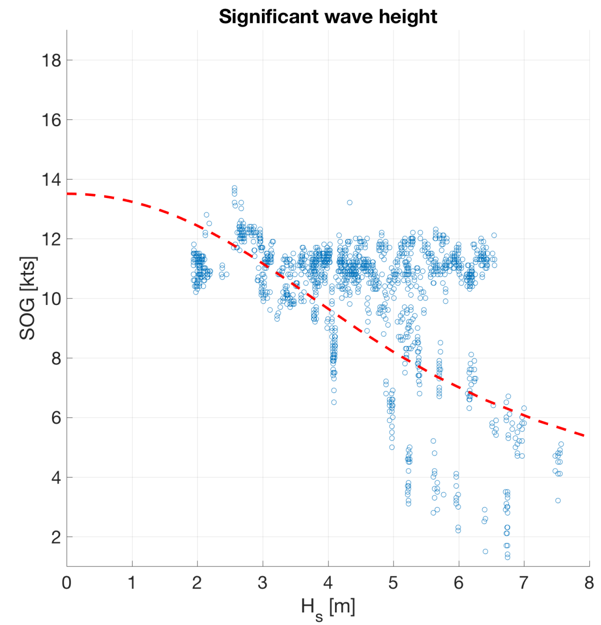


Vessel ID: **002**

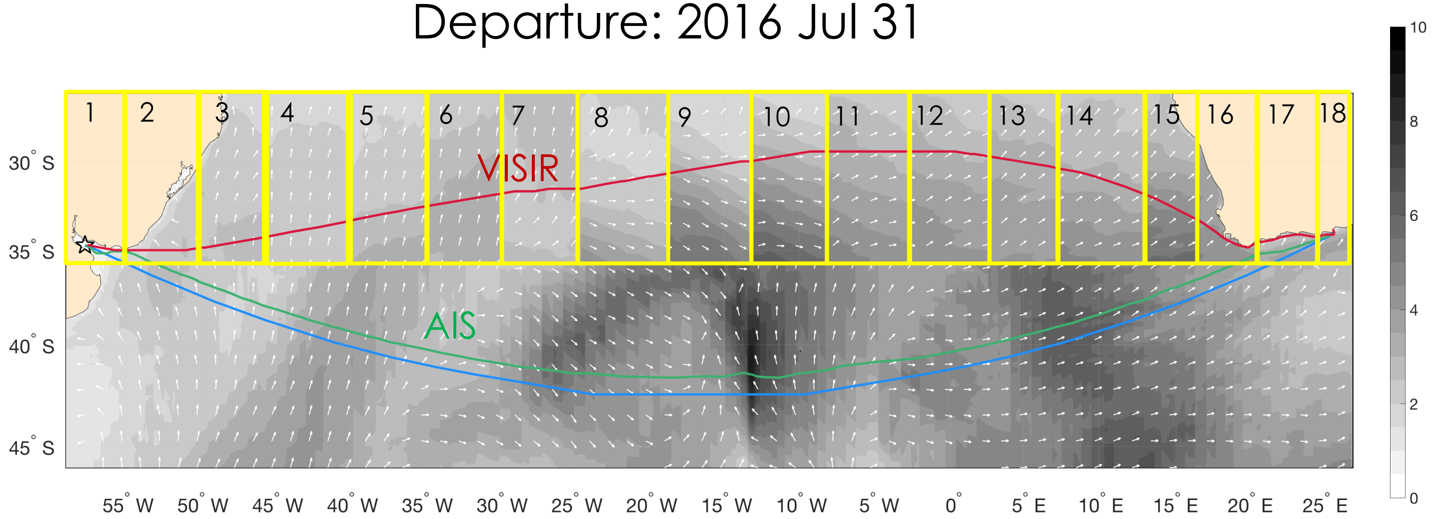
(AIS: waves encountered late)

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

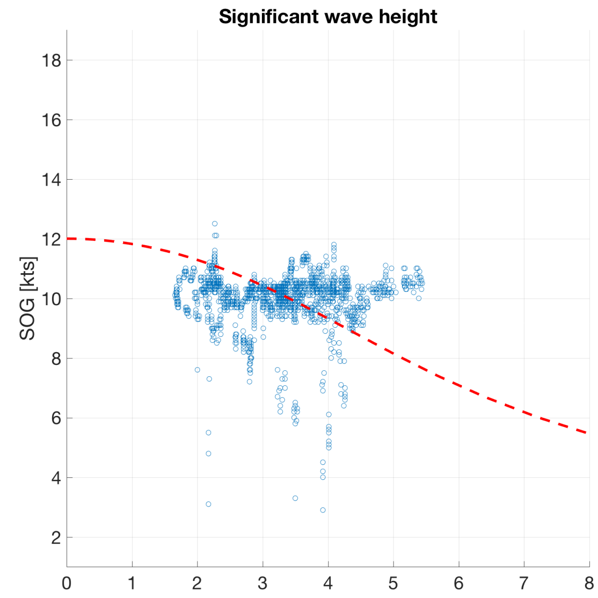


Vessel ID: **051**

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

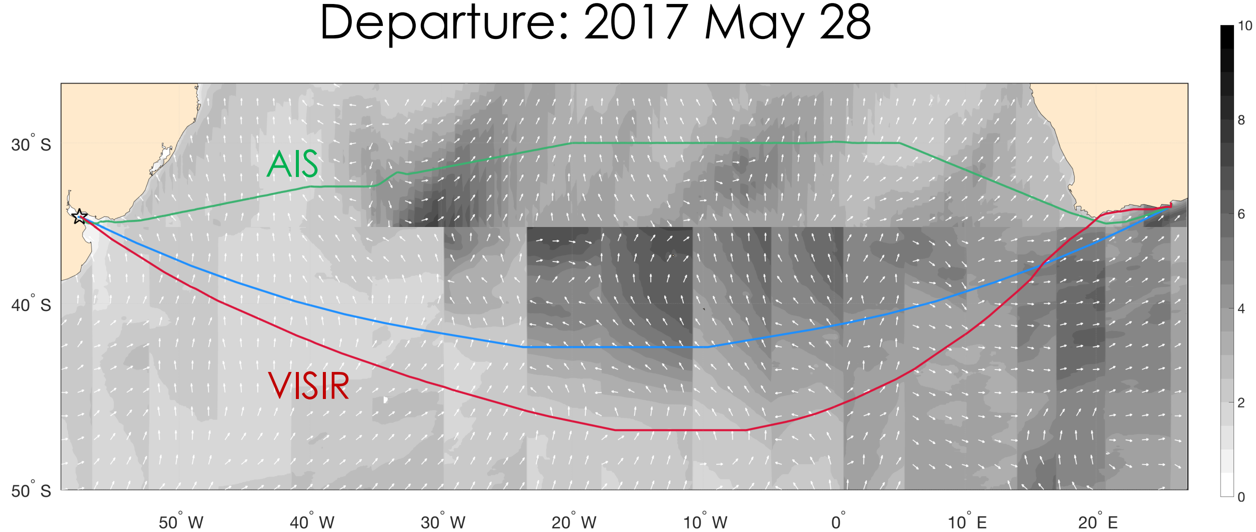
V_{max}= 12.0 kts
P_{max}= 8 700 kW

T_v= 391 hr
T_a= 447 hr
T_g= 406 hr



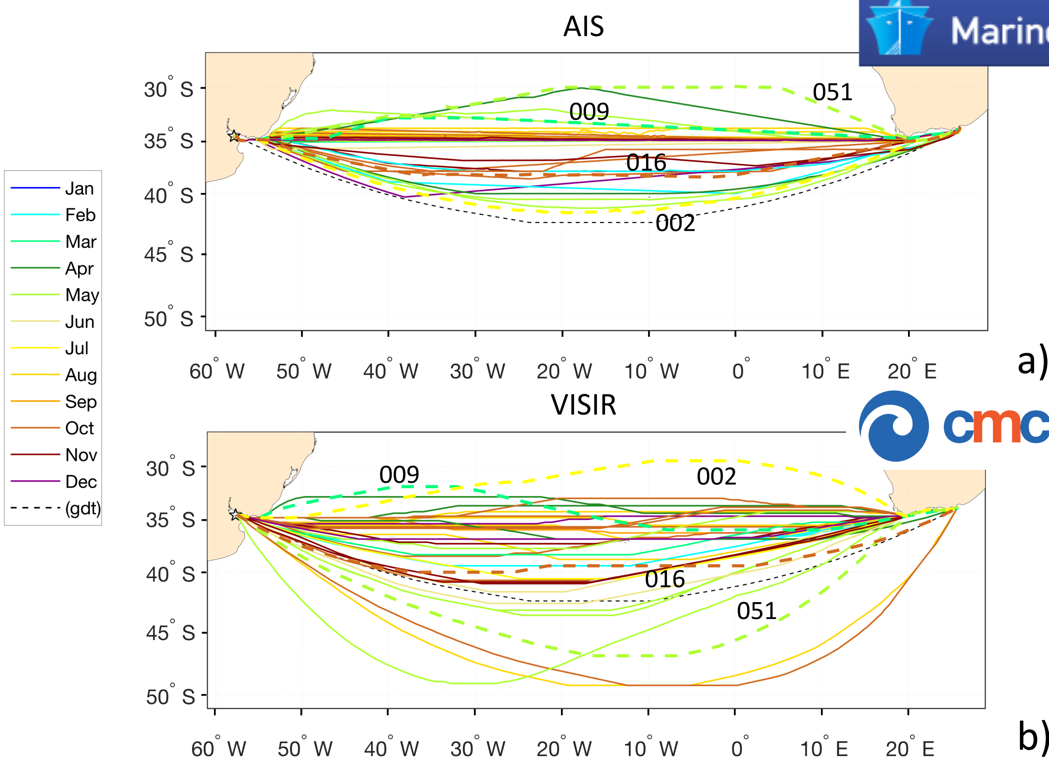
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

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

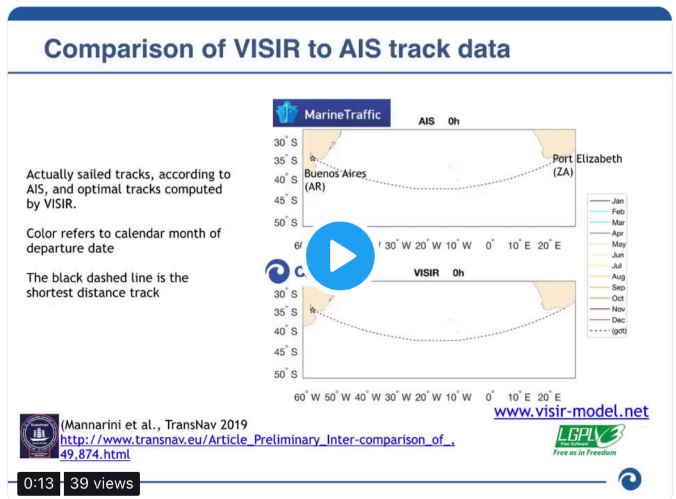
Some VISIR tracks even South of the geodetic

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



7:56 AM - 13 Jun 2019

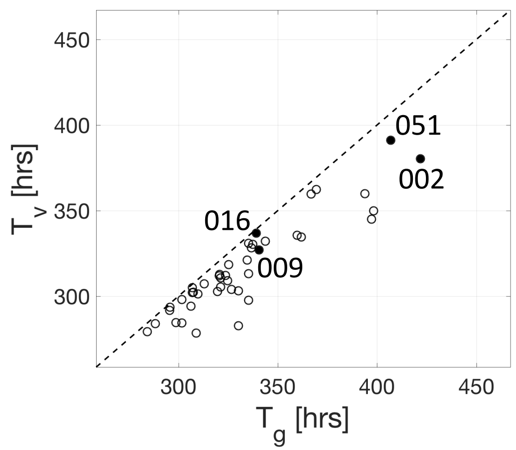
1 Retweet 1 Like

1 1

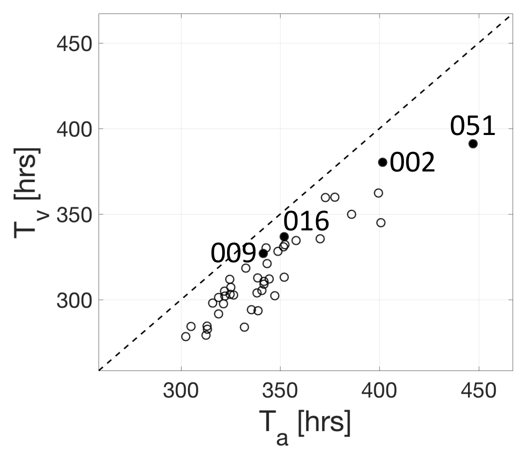
Methodology/Results

7. Statistical analysis of track durations

Duration VISIR



a)



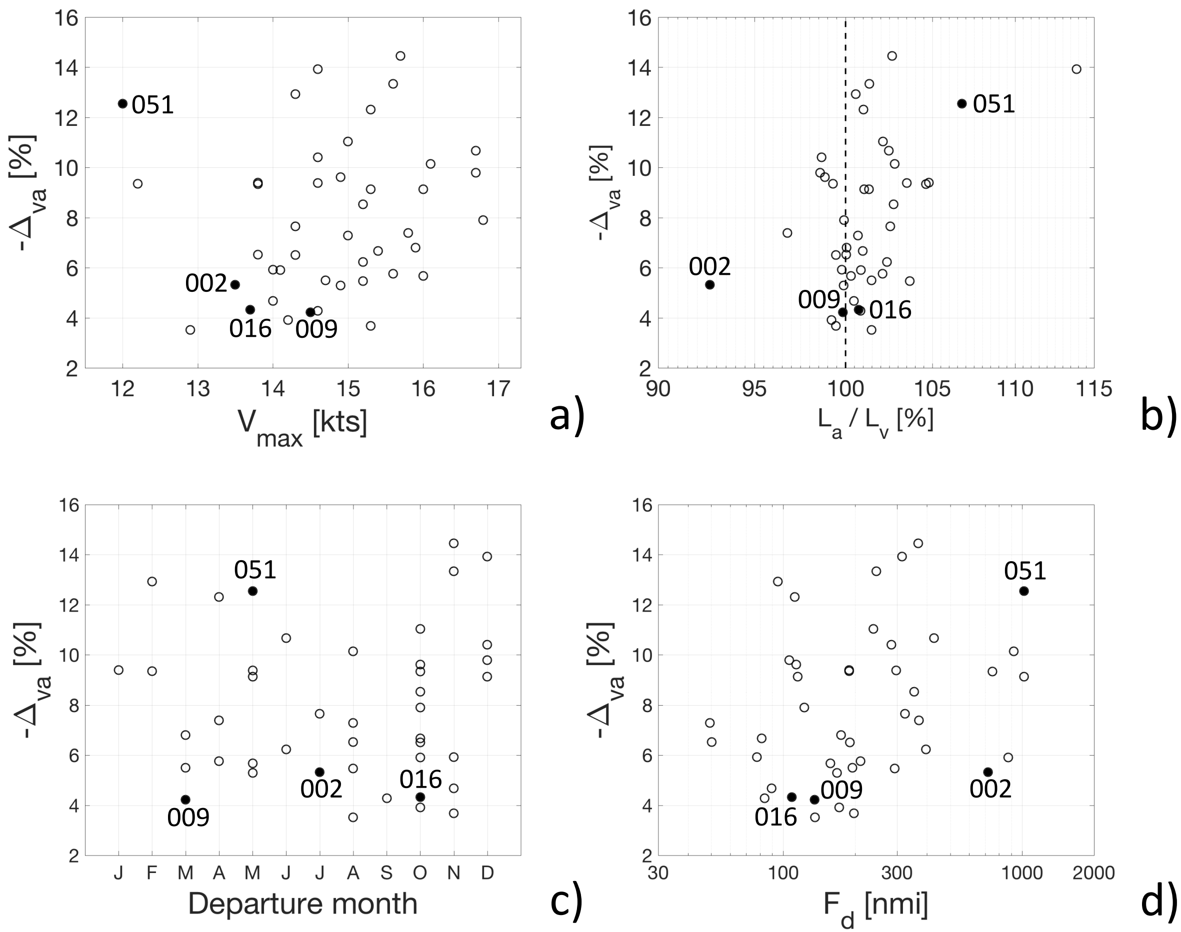
b)

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



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 ➔ L_a/L_v ~ 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

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VISIR References www.visir-model.net

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

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G. Mannarini, N. Pinardi, G. Coppini, P. Oddo, and A. Iafrati. VISIR-I: small vessels – least-time nautical routes using wave forecasts. *Geoscientific Model Development*, 9(4):1597–1625, 2016.

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